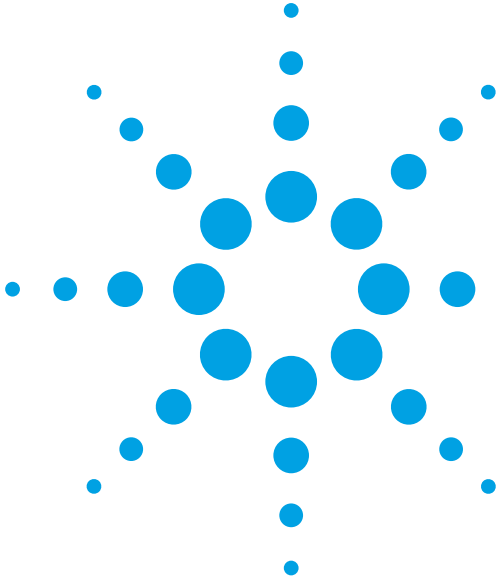
Agilent 3499A/B/C

Switch/Control System



User's Manual

Agilent Technologies

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Earth ground symbol.

Chassis ground symbol.

WARNING

Only qualified, service-trained personnel who are aware of the hazards involved should remove the cover from the instrument.

WARNING

For continued protection against fire, replace the line fuse only with a fuse of the specified type and rating.

User's Guide

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Revision A, September 1999
Revision B, April 2000
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Revision D, November 2002
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Agilent 3499A/B/C Switch/Control System

Agilent 3499A/B/C at a Glance

The Agilent Technologies 3499A/B/C Switch/Control System provides a convenient mechanical and programming environment for a variety of plug-in modules. With appropriate plug-in modules, the Switch/Control System provides high density/high speed switching and digital I/O capability.

Switch/Control System Features

- Intuitive and easy-to-use user interface
- GPIB (IEEE 488) or RS-232 interface control
- External triggering capability
- Built-in 4-bit digital I/O port
- Store and recall up to 50 customized instrument setups
- SCPI (Standard Commands for Programmable Instruments) compatibility
- Relay cycle count information for preventive maintenance
- Downloadable firmware upgrades

Agilent 3499A Features

- Five plug-in slots
- Full rack width

Agilent 3499B Features

- Two plug-in slots
- Half rack width

Agilent 3499C Features

- Nine plug-in slots
- Full rack width

Note: *Unless otherwise indicated, this manual applies to all Serial Numbers.*

Plug-in Modules at a Glance

The Agilent 3499A/B/C mainframes support a variety of plug-in modules to make test system configuration easy. Each module is described in more detail later in this manual.

Multiplexer Modules

N2260A 40-Channel MUX Module (armature relays)
N2266A 40-Channel MUX Module (reed relays)
N2270A 10-Channel High Voltage MUX Module
44470A 10-Channel MUX Module
44470D 20-Channel MUX Module

General Purpose Relay Modules

N2261A 40-Channel GP Relay Module
N2267A 8-Channel High Current GP Module
44471A 10-Channel GP Relay Module
44471D 20-Channel GP Relay Module
44477A 7-Channel Form-C Relay Module

Matrix Modules

N2262A 4 x 8 Matrix Module
44473A 4 x 4 Matrix Module

High Frequency Switching Modules

N2268A 50Ω 3.0 GHz Dual 4-to-1 MUX Module
N2272A 1 GHz RF 1-to-9 MUX Module
N2276A/B Dual 1-to-6 (4) Microwave MUX/Attenuator Module
44472A Dual 4-Channel VHF Switch Module
44478A/B 50Ω/75Ω 1.3 GHz Multiplexer
44476A 3-Channel 18 GHz Switch Module
44476B 2-Channel Microwave Switch Module

Optical Switch Modules

N2280A Optical Switch Quad 1-to-2 MUX Module
N2281A Optical Switch Dual 1-to-4 MUX Module
N2282A Optical Switch 1-to-8 MUX Module

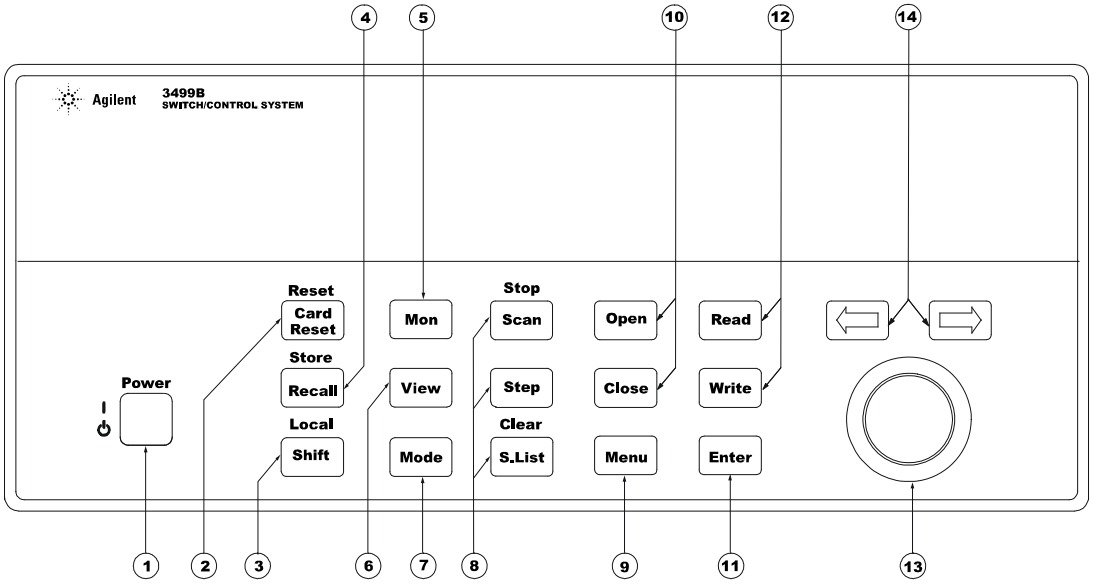
Digital I/O Modules

N2263A 32-Bit Digital I/O Module
44474A 16-Bit Digital I/O Module

Multifunction/Special Purpose Modules

N2264A 12-Channel GP & 3-Channel High-current GP & 16-Bit Digital I/O
N2265A 4 x 4 Matrix & 16-Bit Digital I/O Module
44475A Breadboard Module

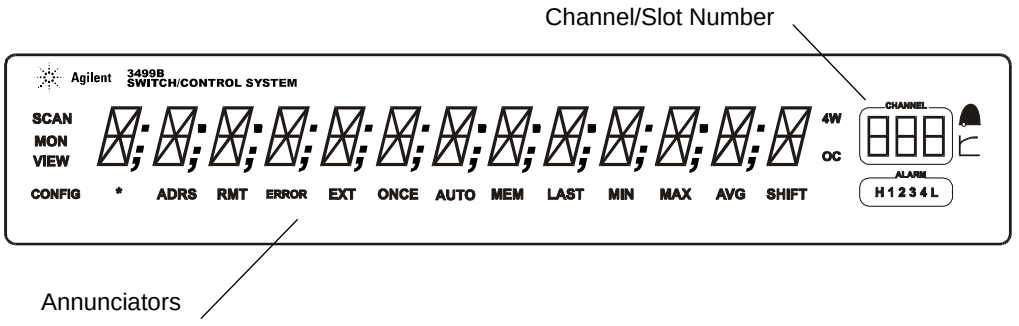
The Front Panel at a Glance



1. Power On/Standby	**8. Scan Keys** (see page 85)
2. Reset Module/Instrument	**9. Main Menu**
3. Shift/Local	**10. Open/Close Relay Channels**
4. Store/Recall Instrument State	**11. Enter a Value/Confirm Selection**
5. Monitor Channel/Port/Module	**12. Read/Write Digital I/O Ports**
6. View Menu	**13. Knob**
7. Mode Menu	**14. Navigation Arrow Keys**

Note The front panel shown above is the Agilent 3499B. The 3499A and 3499C front panels are similar and have identical functionality.

The Display at a Glance



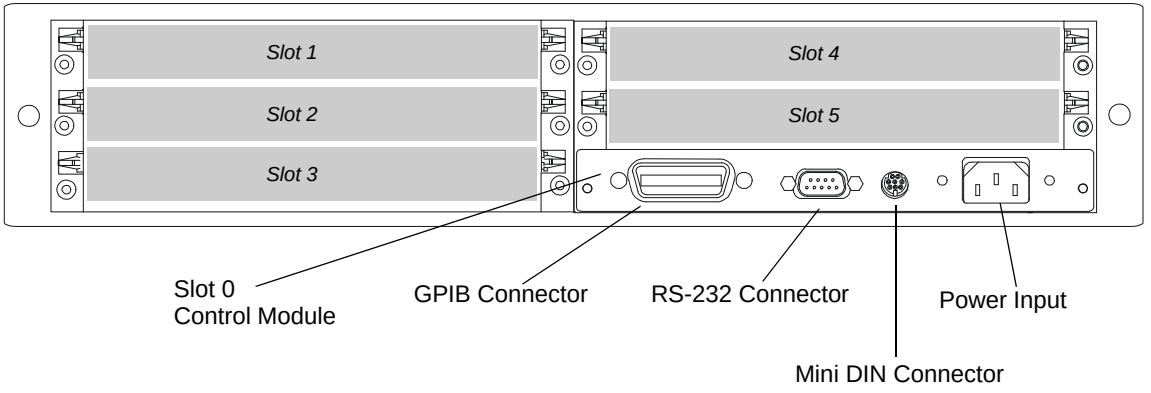
The display is divided into several areas. The channel and slot number is always displayed on the right corner of the display. The main area, which is in the center of the display, is primarily used to display channel status (open or closed), information messages, menu items, prompt information, error messages, and so on. Around the display are annunciators to indicate various states of the instrument operation. The annunciators are summarized below.

Annunciator	**Indication**
SCAN	Scan is initiated.
MON	Instrument is in monitor mode.
VIEW	Scan list, errors or relay cycle counts are being viewed.
CONFIG	Any configuration key has been pressed.
*	Instrument is advancing a scan step.
ADRS	Instrument is active on the remote interface.
RMT	Instrument is in remote mode.
ERROR	Error queue is not empty.
EXT	Scan is waiting for external trigger source.
SHIFT	Shift key has been pressed.

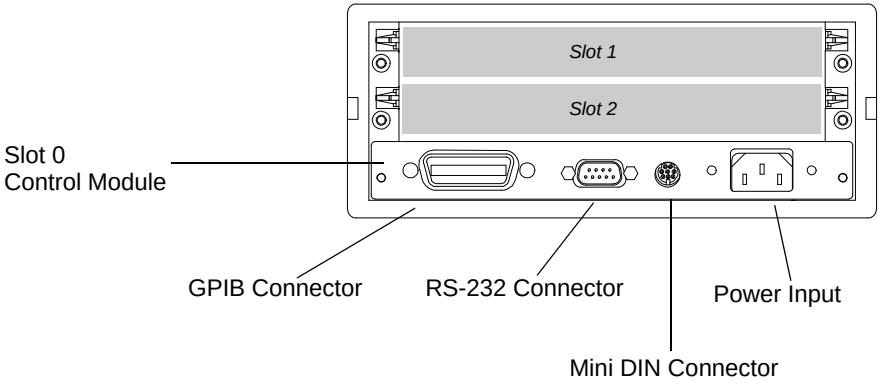
Other annunciators in the display are not used in the Agilent 3499A/B/C system.

The Rear Panel at a Glance

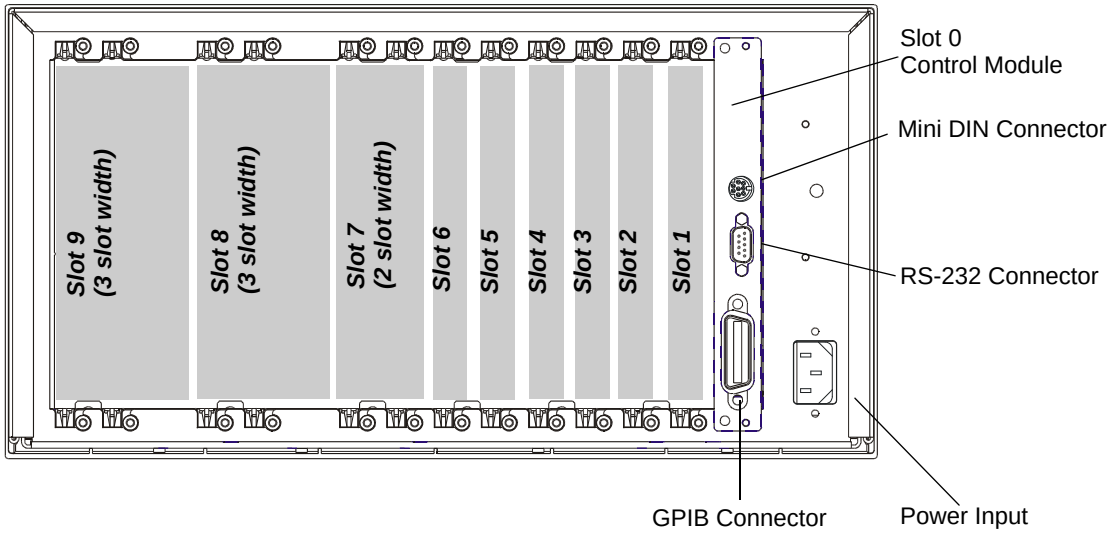
The figure below shows the Agilent 3499A rear panel.



The figure below shows the Agilent 3499B rear panel.



The figure below shows the Agilent 3499C rear panel.
Option FP1 (1-slot) and FP2 (2-slot) filler panels can be ordered to cover any unused slots.

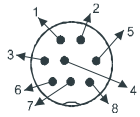


WARNING *For protection from electrical shock, the power cord ground must not be defeated.*

The Mini DIN Connector

The rear panel mini DIN connector is used to make connections to external triggers and the built-in digital I/O port. An Agilent N2289A cable (mini DIN to D9) can be ordered to assist connections to external devices. The figure below shows the pins used in the mini DIN connector.

Mini DIN Connector



Pins	Description
1	DIO 091
2	DIO 092
3	DIO 093
4	DIO 094
5	GROUND (TRIG)
6	GROUND (DIO)
7	Ext.Trig.In
8	Ext.Trig.Out

In This Book

Quick Start Chapter 1 prepares the switch/control system for use and helps you get familiar with a few of its front-panel features.

Front-Panel Menu Operation Chapter 2 introduces you to the front-panel menu and describes some of the switch/control system's menu features.

System Overview Chapter 3 gives an overview of a switch/control system, describes how parts of the system work together, and describes the channel addressing scheme used.

Features and Functions Chapter 4 gives a detailed description of the switch/control system's capabilities and operation. This chapter is useful for operating the switch/control system from the front panel or the remote interface.

Remote Interface Reference Chapter 5 contains a SCPI language reference used to program the switch/control system over a remote interface.

Error Messages Chapter 6 lists the error messages that may appear as you are working with the instrument.

Plug-in Modules Chapter 7 gives detailed information for each plug-in module. Each module and its wiring is described. Additionally, wiring information for terminal blocks, crimp-and-insert connections, BNC and SMA connections, and special cables is included.

Application Programs Chapter 8 contains several remote interface application programs to help you develop programs for your switch/control system.

Specifications Chapter 9 lists the technical specifications for the mainframe and plug-in modules.

If you have questions relating to the operation of the Agilent 3499A/B/C, call **1-800-452-4844** in the United States, or contact your nearest Agilent Technologies Sales Office.

If your 3499A/B/C fails within one year of purchase, Agilent will either repair or replace it free of charge. Call **1-877-447-7278** in the United States (and ask for "Agilent Express") or contact your local Agilent Technologies Sales Office.

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Quick Start

1

Quick Start

This chapter describes the procedure to install the plug-in modules into an Agilent 3499A/B/C mainframe and mount the mainframe onto a system rack. The basic operations of the Agilent 3499A/B/C Switch/ Control System is also described. The chapter contents include:

- To Prepare the Instrument for Use, on page 15
- To Install a Module in the 3499A/B/C, on page 17
- Basic Operation, on page 19
- To Rack Mount the 3499A/B/C, on page 23

To Prepare the Instrument for Use

1 Check the list of supplied items

Verify that you have received the following items with your Agilent 3499A/B/C mainframe:

- ? One power cord;
- ? This *User's Manual*;
- ? One *Quick Reference Guide*;
- ? One Tie Down Clip 03499-21002 (for Agilent 3499B only);
- ? Any plug-in modules that you ordered are delivered in separate shipping containers.

2 Connect the power cord and turn on the instrument

1. Connect the 3499A/B/C to an AC power source with the supplied power cord.
2. Push the **Power** switch located on the lower left side of the front panel.

3. On power-up, every segment in the display will light up briefly, including all annunciators. Following this "starburst" display, the internal self-test will begin.
4. If the self-test passes[1], the default system mode and the GPIB address are displayed, together with a "beep" sound. Then the display shows the instrument model number and the active slot (slot 0).

SCPI GPIB 9
3499 0

[1] If the self-test failed, the failure will be displayed on the front panel. For details of all self-test errors, refer to "Error Messages" starting on page 165.

When shipped from the factory, the SCPI mode and the GPIB interface address of "9" are used. Slot 0 refers to the built-in controller board of the switch/control system.

If the Instrument Does Not Turn On

1. Verify that the power cord is firmly plugged into the power receptacle on the rear panel of the 3499A/B/C.
2. Make sure that the power source the 3499A/B/C is plugged into is energized.
3. Verify that the 3499A/B/C is turned on.

Note If the 3499A/B/C DOES NOT turn on after you perform the above procedure, contact your nearest Agilent Service Center (see page 8).

To Install a Module in the 3499A/B/C

The plug-in modules you ordered were not installed in the mainframe. The figure on page 18 shows how to install a plug-in module into the 3499B mainframe. Other mainframes use similar procedures.

WARNING *Disconnect the power cord from the rear panel of the mainframe prior to installing or removing any modules.*

Caution Use anti-static procedures when configuring, installing or removing any plug-in modules. To prevent contamination to the modules that could degrade performance, handle the modules by the side edges or shields only. Do not touch the board surfaces or components.

Each plug-in module may have terminal block(s) and/or the cables for wiring to external circuits. These terminations are also shipped separately.

For more details about terminal blocks, cables, and connections, see "Terminals and Connections Information" on page 275.

Caution In order to stay within the 20W power limit set for convection cooling, no more than three (3) N2266A 40-Channel MUX Modules should be installed in an Agilent 3499A mainframe; the remaining two slots must remain empty. Other module combinations are acceptable; for example, two N2266A MUX modules plus any combination of other Agilent modules is permissible. This limitation does not apply to the 3499B or 3499C mainframes.

Module Removal

To remove a plug-in module from the Agilent 3499A/B/C mainframe, reverse the procedures shown on page 18.

STEP 1

1. Face the mainframe rear panel toward you.
2. Select a slot in which the module is to be installed.

STEP 2

1. Hold the sides of the module, component side **down**, by the metal shields.
2. Insert the module into the slot guides and slide the module toward the front of the instrument.
3. Push firmly until the module “snaps” into place.
4. Push both plastic levers inward to lock the module.

STEP 3 (for modules with terminal blocks)

1. Wire the screw terminal block (module dependent, refer to chapter 7 for details).
2. Attach the screw terminal block to the plug-in module.

STEP 4 (for modules with terminal blocks)

1. Push firmly until the terminal block “snaps” into place.
2. Secure the screw terminal block with the two screws (Torque < 8 in-lbs).

Module installation

Basic Operation

An Agilent 3499A/B/C Switch/Control System can be easily operated from the front-panel, or programmed with SCPI commands over the remote interface.

The following sections are only intended to show the basic front-panel operation. For detailed front-panel operation, refer to the "Front-Panel Operation" chapter on page 27. For more information about programming the instrument, refer to the "Remote Interface Reference" chapter on page 113.

Channel Addressing

A channel refers to an individual relay on a switching module, or an individual bit/port on a digital I/O module. The channel address is in the form of *snn*, where *s* represents slot number and *nn* represents a channel number.

For all mainframes, slot 0 refers to the 3499 controller board. Valid slot numbers are:

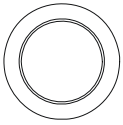
3499A	slots 0 through 5
3499B	slots 0 through 2
3499C	slots 0 through 9

The channel number, *nn*, is plug-in module dependent. For additional information about channel numbers of individual plug-in modules, refer to the table beginning on page 70.

To Select a Slot and Channel

When the instrument is first turned on, the display shows the model number and the slot number of the controller board.

3499	*0*



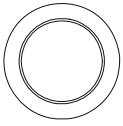
Use the knob to select a channel on the active slot. For example, with the display shown above, turning the knob to the right will select the first of the individual built-in digital I/O ports.

DIN	*090*

The "DIN" indicates the port is set for a digital input operation. As the knob is turned, the additional ports are displayed followed by any installed plug-in modules.

If you have installed one or more plug-in modules, you can select the module by pressing the right arrow key. For example, if an N2260A (40-channel MUX module) is installed in slot 1, pressing the right arrow key will show the module name and slot number.

N2260A	*1*

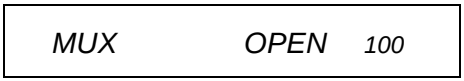


Turning the knob will then step through the individual channels on that module.

MUX	*OPEN*	*100*

To Open or Close a Channel

When a channel is selected, you can open or close the channel using the front panel keys. For example, with an N2260A 40-channel MUX installed in slot 1, select channel 00 as described on the previous page.

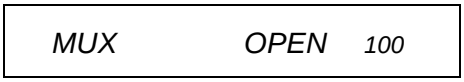


Close

Press the **CLOSE** key to close the channel.

Open

Press the **OPEN** key to open the channel



In this manner, you can select and control as many channels as you need. The N2260A has 40 channels numbered 0 through 39 (in slot 1, 100 through 139). You may also select additional plug-in modules and channels by turning the knob.

To Open All Channels on a Module

You can open individual channels on a module one at a time as described above. There are times, however, when it would be more expedient to open all channels on a module at once.

Use the arrow keys to select the module to work with. You cannot have an individual channel selected for this operation. For example, select the module in slot 1 (using the N2260A as an example) to show a display similar to this:

N2260A 1

Press and hold the card reset key. When you first press the key, the display shows:

HOLD TO RESET

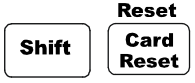
When the card has been reset, the display briefly shows:

RESET CARD

and then returns to:

N2260A 1

To Reset All Modules



You can reset all channels on all modules in the mainframe at once. Press the shift key and then press and hold the reset key. The display shows:

HOLD TO RESET

When the mainframe has been reset, the display will briefly show the reset and then return to the slot or channel display.

RESET . . .

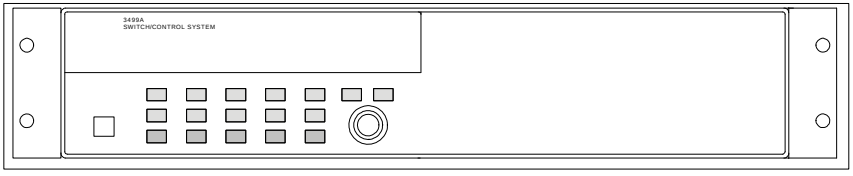
To Rack Mount the 3499A/B/C

You can mount the Agilent 3499A/B/C on a standard 19-inch EIA rack cabinet with the optional rack-mounting kits. The instructions and mounting hardware are included with each rack-mounting kit.

Agilent 3499A

To rack mount a 3499A, the full-rack-width mainframe, order either:

- Rack-mount kit with handles, part number 5183-7170, or
- Rack-mount kit without handles, part number 5183-7171.

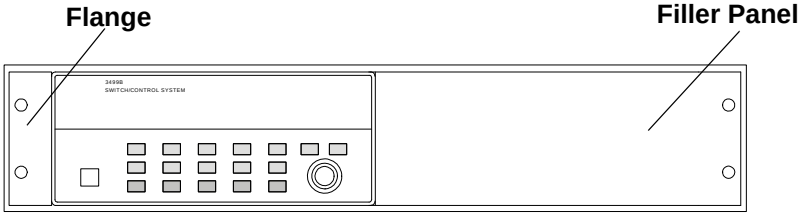


To Rack Mount an Agilent 3499A

Agilent 3499B

To rack mount a single 3499B, order either:

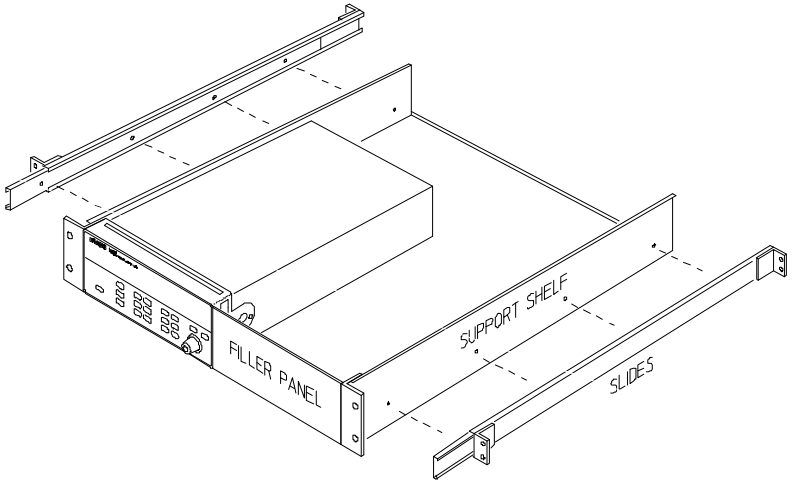
- Adapter kit, part number 5183-7172
  (includes the flange and filler panel).



To Rack Mount a Single Agilent 3499B with Adapter kit 5183-7172

OR

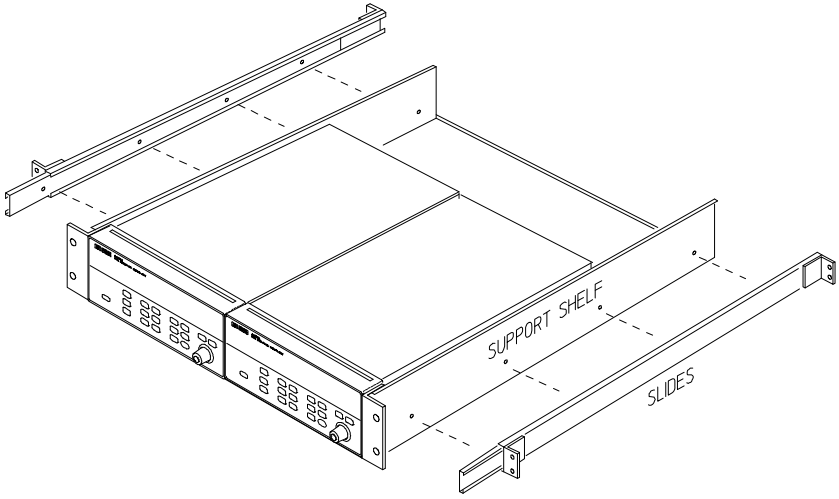
- A Support Shelf, part number 5063-9255,
- A slide kit, part number 1494-0015,
- And a filler panel, part number 5002-3999.



To Rack Mount a Single Agilent 3499B on a support shelf

To rack mount two Agilent 3499B's side-by-side (or any System II instrument next to an Agilent 3499B), order:

- A Support Shelf, part number 5063-9255,
- And a slide kit, part number 1494-0015.

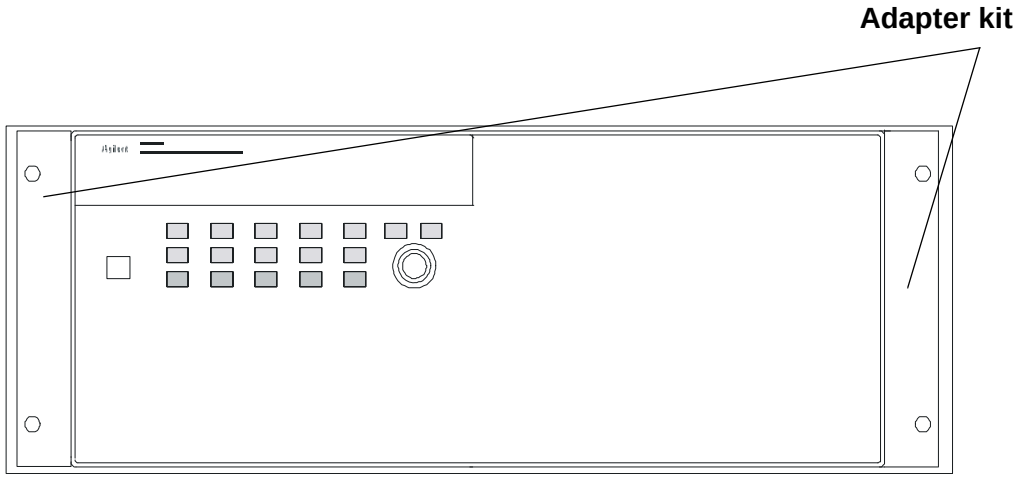


To Rack Mount Two Agilent 3499B's Side-by-side

Agilent 3499C

To rack mount an Agilent 3499C, order either:

- Adapter kit without handles, part number 5063-9216, or
- Adapter kit with handles, part number 5063-9223.



To Rack Mount an Agilent 3499C

Filler Panels

Order filler panels to cover any unused slots in an Agilent 3499A/B/C.

- 1-slot filler panel, part number 03499-00023 (option FP1)
- 2-slot filler panel, part number 03499-00024 (option FP2)

Front-Panel Operation

Front-Panel Operation

The Agilent 3499A/B/C mainframes all operate the same from the front-panel. This chapter does not give a detailed description of every possible front-panel operation. It does, however, give you a good overview of the front-panel menus and front-panel keys. See the "Features and Functions" chapter on page 77 for additional discussions of the instrument's capabilities and operation. This chapter contents include:

- To Power On the Instrument, on page 29
- To Monitor a Channel or a Slot, on page 29
- To Use a Digital I/O Port, on page 31
- To View Instrument Errors, on page 36
- Scanning Operation, on page 38
- To Pair Two Modules Together, on page 41
- To Configure for External Trigger, on page 42
- To Configure the Power-on State, on page 44
- To Configure the Remote Interface, on page 46
- To Perform a Self-test, on page 51
- To Query the Firmware Revision, on page 52
- To Query the Serial Number, on page 53
- Local/Remote Control, on page 54

The following conventions are used for the front-panel operation.

- All keys on the front-panel keyboard are expressed in bold font and normally associated with a "press". For example, press **Mon**.
- All the front panel display annunciators are expressed in bold font followed by an "annunciator". For example, **MON** annunciator.
- The information shown on the front panel display is enclosed within a pair of quotation marks.

2

To Power On the Instrument

To power on the instrument, press the **power** switch on the front panel. If the instrument is powered up for the first time, the instrument will use the factory default settings as shown on page 74. Otherwise, the instrument will power on to the state specified. Refer to "To Configure the Power-on State", on page 44 for more details.

To Monitor a Channel or a Slot

You can continuously monitor the current status of a particular switching channel, a digital I/O port, or an entire plug-in module. Monitoring from the front panel is especially useful when developing and debugging remote interface commands.

1. Press the monitor key, the **MON** annunciator lights up to indicate the instrument is in the monitoring state.

2. Select the slot or the channel/port to be monitored. The displayed information depends on the selected module type. Typical displays are shown in the table on page 81.

3. If only part of the channel status on the module can be displayed at one time, press **Enter** to display the next part.

   For multiplexer modules and GP Relay modules, 10 channels can be displayed at one time; for matrix modules, one Row or one Column can be displayed at one time; for digital I/O modules, two 8-bit ports can be displayed at one time. For multifunction modules, the first function on the module is displayed, then the next.

4. Press the monitor key again to end monitoring (the **MON** annunciator turns off).

Note

The built-in digital I/O bits/port (on the controller module) can be monitored either individually as bit channels (numbered *091* through *094*) or as a 4-bit port (numbered *090*). However, the individual bit channels on a digital I/O or multifunction module (with a DIO function) cannot be monitored.

2

.

Display	Description
1:0,,,,,,6,,,9, 2	The display for a multiplexer or a GP relay module. This display indicates that the monitored module is in Slot 2 and channels 10, 16, and 19 are closed.
ROW 3:,1,,3,,,6,7 3 *0;,,3,COL 3, 3*	The display for a matrix module. The top is the row information, indicating that the relays on Row 3, Columns 1, 3, 6 and 7 of the module (in Slot 3) are closed. The lower display is the column information, indicating that relays on column 3, row 0 and 3 are closed.
00:H255 L254. 4	The display for a digital I/O module. The first 2 digits on the left ("00" in this case) represents the "L" 8-bit port address. Adding one to this value, the "H" 8-bit port address is obtained. Data with a trailing decimal point indicates that the last operation on that port was a WRITE, data without a trailing decimal point indicates that the last operation on that port was a READ. This display shows that the data last read from Port 401 is 255 and the data last written to Port 400 is 254.
DIO 12 090 *DOUT 0 091*	The top display is for the built-in digital I/O Port *090* (control module) and the data from the last operation. The lower display indicates that data last written to the bit channel 091 is 0.
ROW 0:,1,,3, 5 *00:H255 L254. 5*	For a multifunction module, the first function on the module is displayed, then the next. This display is an example of a multifunction module with matrix and DIO functions (in slot 5).

To Use a Digital I/O Port

You can work with a digital I/O module as a port (all eight bits) or as individual bits.

Reading a Digital I/O Port

You can read data from the built-in 4-bit digital I/O port, or any one of the 8-bit ports on a digital I/O or multifunction module (with a DIO function). You can read the entire port (all bits) when you select the slot (for example, the built-in port is channel 090). Alternately, you can read an individual bit by selecting the channel (for example the first bit in the built-in port is channel 091).

Perform the following procedure to read from a port:

1. Select a digital I/O port. Use the knob to select the slot and channel number. The channel number is in the form of *snn*, where *s* is the slot number and *nn* is the channel number.

Read

2. Read the data read from the selected port. For example, the display below shows the data read from port 401.

DIN 255 401	Decimal format (default)
DIN 11111111 401	Binary format

The data display format of individual 8-bit ports can be specified either in binary or decimal formats (as described on page 34). Once specified, the format applies to all input and output operations on the same port.

2

Writing to a Digital I/O Port

You can write data to the built-in digital I/O port (numbered *090*) or to one of the built-in digital I/O port bits (numbered *091* through *094*), or any one of the 8-bit ports on a digital I/O or multifunction module (with a DIO function). To write to a port:

1. Select a digital I/O port. Use the knob to select the slot and channel number. The channel number is in the form of *snn*, where *s* is the slot number and *nn* is the channel number. In the display, "DIN" indicates that the last operation on the port was a READ, and "DOUT", a WRITE.

DIN	401

Write

2. Press the **Write** key. "DOUT" is displayed to indicate the port is now an output port. The current port value is displayed.

DOUT	255 401

3. Edit the value. Use the arrow keys to select the to-be-edited bit (the digit to be edited is set to half bright in the display).

   Turn the knob to modify the value. Use the arrow keys to select the next digit and the knob to modify its value.

DOUT	254 401

Enter

4. When the value is the one desired, press **Enter** to output the data to the selected port.

5. Press **Write** again to cancel the current write operation.

Note

Data display format of individual 8-bit ports can be specified either in binary or decimal values (refer to the procedure on page 34). Once specified, the format applies to all input and output operations on the same port.

To Configure a Digital I/O Module

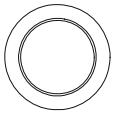
Digital I/O modules can be configured for handshake modes and control line, flag line, and I/O line polarity. Use the **Mode** menu to configure digital I/O parameters. See "Digital I/O Operation" on page 95 for detailed descriptions of the operating modes. Only plug-in modules can be configured this way, the built-in digital I/O port (control module) can only be configured at the port level (see page 34).

The following procedure configures a plug-in digital I/O module to use a two line digital handshake mode (mode 5) for data transfers.

1. Select the slot in which a digital I/O or multifunction module is installed. The channel number is in the form of *snn*, where *s* is the slot number and *nn* is the channel number.

2. Press the **Mode** key. The **CONFIG** annunciator lights up in the display and the first-level menu is shown.

3. Press **Enter** to begin the configuration. The display shows the second-level menu choice.



4. Turn the knob until the desired flow control mode (i.e., MODE 5) is displayed. The displayed mode is half-bright.

2

Enter

5. Press **Enter** to select the new mode. The display changes to show the next menu level.

CONT POL POS	*4*

Mode

6. You may change other configuration parameters as desired using the same procedure. When all desired configurations have been made, press the **Mode** key to exit the configuration menu. The **CONFIG** annunciator turns off.

To Configure a DIO Port

You can configure an individual digital I/O port to change the data polarity and the display format. The following procedure changes the built-in digital I/O port to display in binary number format.

1. Select a digital I/O port (i.e., port 090). The channel number is in the form of *snn*, where *s* is the slot number and *nn* is the channel number.

DIN	*090*

Mode

2. Press the **Mode** key. The **CONFIG** annunciator lights up in the display. The first level menu is shown:

DATA POLARITY	*090*

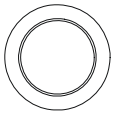
3. Turn the knob to select the second menu level

DISP FORMAT	*090*

Enter

4. Press **Enter** to select the format parameter.

DECIMAL	*090*



5. Turn the knob until the desired data display format (i.e., BINARY) is displayed.

BINARY	*090*

6. Press **Enter** to make the change and return to the first level of the Mode menu.

DISP FORMAT	*401*

Mode

7. Press **Mode** again to exit the current configuration, the **CONFIG** annunciator turns off.

Note

Once you have selected the data display format for a port, it applies to both input and output operations on that port.

2

To View Instrument Errors

You can view errors from the front panel. This feature is especially useful when developing remote instrument control. If an error occurs, the **ERROR** annunciator in the display will light. Errors are stored in the error queue in the order they occur. You read the errors in the same order. After all errors have been read, the queue is empty and the **ERROR** annunciator turns off. To view instrument errors:

View

1. Press the **View** key. The **VIEW** annunciator lights up and the display shows the first menu level.

```
ERROR                    0
```

Enter

2. Press **Enter** to view the first error.

   a. If no error is in the error queue (the **ERROR** annunciator is off), the display shows "NO ERROR" and then automatically returns to the first level of the View menu.

```
NO ERROR                 0
```

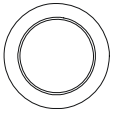
```
ERROR                    0
```

   b. If there are errors (the **ERROR** annunciator is on), the first error in the error queue is displayed.

```
01:ERR -109
```

   Press the right arrow key to scroll the display to show the entire error message.

```
MISSING PARAMETER
```



3. Turn the knob to view other errors in the error queue (if any).

Enter

4. Press **Enter** to return to the first level of the View menu, the **ERROR** annunciator turns off.

View

5. Press **View** again to exit the View menu operation, the **VIEW** annunciator turns off.

Note

All errors are cleared, and the **ERROR** annunciator turns off, once the error queue is viewed. See the "Error Messages" chapter on page 165 for a complete list of error messages.

2

Scanning Operation

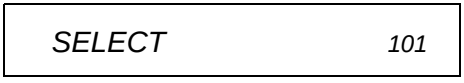
The instrument allows you to combine an external measurement device such as a Digital Multimeter (DMM) with multiplexer channels to create a *scan*. During a scan, the instrument closes the configured multiplexer channels one at a time to allow a measurement to be made on that channel.

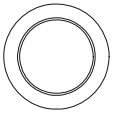
Before initiating a scan, a scan *list* must be set up. You can also specify an arm source, a trigger source, and the number of sweeps (a sweep is one pass through the scan list) to control the scan process. All these can be done from the **S.List** menu. The procedure in this chapter describes a simple scan from the front panel. For more information about scanning and using the parameters to control a scan, see page 85.

To Create a Scan List

1. Press the **S.List** key to enter the scan list menu. The **CONFIG** annunciator lights up and the first level of the menu is displayed.

2. Press **Enter** to begin the channel selection.





3. Turn the knob to select the first channel for the list (e.g., 103).

4. Press **Enter** to add the channel into the scan list. The starburst character lights in the display to indicate the channel is now a part of the scan list.

5. Repeat step 3 and 4 to add additional channels to the list.

S.List

6. When the desired channels have been added, press the **S.List** key again to return to the first level of the menu.

ADD TO SCAN	107

S.List

7. Press **S.List** again to exit the menu. The **CONFIG** annunciator turns off.

To Perform Scanning

After the scan configuration is complete, the actual scan can be performed.

Step

1. Press the Step key to close the first channel in the scan list.

Step

2. Press the Step key again to open the first channel and close the next channel in the list.

Scan

This procedure shows a simple way to scan, one channel at a time for each press of a front panel key. You can also press the **Scan** key to scan all channels in the list according to the various scan parameters set. In the default parameter state, pressing the **Scan** key will cause all the channels in the list to cycle through at the maximum possible speed. While this occurs, the **SCAN** annunciator is lighted. For details about the scan parameters, see page 85.

To Clear a Scan List

You can clear a scan list once it has been configured.

Shift Clear S.List

1. Press the **Shift** key and then the **S.List** key. The display will briefly show:

CLR SCAN LIST	101

and then return to normal operation.

2

To View a Scan List

You can view which channels are included in a scan list. This example assumes that channels 103 through 107 are included in the scan list.

View

1. Press the **View** key. The **VIEW** annunciator lights up and the display shows the first level menu.

ERROR	*101*

2. Turn the knob until "SCAN LIST" is displayed.

SCAN LIST	*101*

Enter

3. Press **Enter**. The first channel in the scan list is displayed on the channel area.

001 OF 005	*103*

Turn the knob to view other channels in the scan list.

002 OF 005	*104*

Enter

4. Press **Enter** to return to the first level of the View menu.

SCAN LIST	*107*

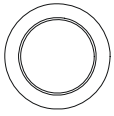
View

5. Press **View** again to exit the View menu. The **VIEW** annunciator turns off.

To Pair Two Modules Together

You can pair two modules together so that they operate as a single unit. The two modules to be paired must be identical (that is, they must have the same model number) and be installed in the same mainframe. When two modules are paired together, any operation on a channel of one module will be duplicated on the corresponding channel of the other module. The example below pairs modules installed in slots 2 and 5.

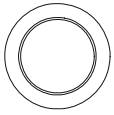
1. Press the **Menu** key. The **CONFIG** annunciator lights up and "**CARD PAIR**" is displayed.



2. Press **Enter**.

   When "FIRST SLOT x" is displayed, turn the knob to select the first slot to be paired (i.e., Slot 2).

   FIRST SLOT 2



3. Press **Enter.**

   When "SECOND SLOT x" is displayed, turn the knob to select the second slot to be paired (i.e., Slot 5).

   SECOND SLOT 5

4. Press **Enter** to return to the first level of the Menu menu.

   CARD PAIR

5. Press **Menu** again to exit the Menu menu. The **CONFIG** annunciator turns off.

2

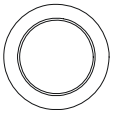
To Configure for External Trigger

You can use one of two modules for an external trigger. The built-in rear panel TRIG IN and TRIG OUT pair (on the control module) or the EI (External Increment) and the CC (Channel Closed) pair on a 44474A module. Only one pair can be used at a time. You can specify which pair to use and whether a trigger out pulse is sent out when a relay is closed during scanning operations. Refer to "Scanning" on page 85 for more details.

Menu

1. Press the **Menu** key. The **CONFIG** annunciator lights up and the display shows the first level menu.

CARD PAIR



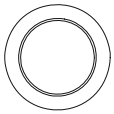
2. Turn the knob to show the second menu item, "CONF EXT TRIG".

CONF EXT TRIG

Enter

3. Press **Enter**. The display shows the next level menu.

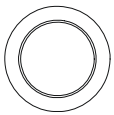
TRIG SLOT 0



Enter

4. Turn the knob to select the slot for the external trigger. Slot 0 (control module) is the built-in external trigger (available at the rear panel mini DIN connector, see page 7). If a 44474A is not installed, only slot 0 will be shown. Press **Enter**. The display shows the current setting for the external trigger.

DISABLE



5. Turn the knob to show the alternate choice.

ENABLE

Enter

6. Press **Enter** to accept the choice and return to the first level menu.

CONF EXT TRIG

Menu

7. Press the **Menu** key to exit the menu. The **CONFIG** annunciator turns off.

2

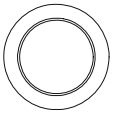
To Configure the Power-on State

Firmware Rev 4.0 ONLY. To read your firmware version, see the procedure on page 52. For more information about firmware revisions, see "Firmware and Control Module Description" on page 59.

An instrument with Firmware REV 4.0 or later can be set to power on to the reset state (see "Factory Default and Reset States" on page 74) or to a state previously stored in a specified memory location. The instrument will return to the specified state the next time it is turned on.

1. Press the **Menu** key. The **CONFIG** annunciator lights up and the display shows the first menu level.

   CARD PAIR



2. Turn the knob until "POWER ON SET" is displayed.

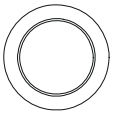
   POWER ON SET

3. Press **Enter** to show the second level menu.

   PWR ON RESET

4. To set the instrument power-on to the reset state, press **Enter**. The instrument will return to the first level menu.

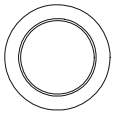
   Alternately, to set the instrument power-on to a stored state: Turn the knob until "USER SET UP" is displayed.



   USER SET UP

5. Press **Enter** to select the stored state to use.

   POWER ON 05



6. Turn the knob to select the desired memory location (i.e., 08).

POWER ON 08

7. Press **Enter** to accept the stored state and return to the first level menu. More information about storing states is given on page 106 of this manual.

POWER ON SET

8. Press the **Menu** key again to exit the Menu menu. The **CONFIG** annunciator turns off.

Note

If the instrument is set to power on to a previously stored setup that is no longer valid, it will automatically power on to the reset state and "RECALL FAILED" will be displayed.

2

To Configure the Remote Interface

The instrument can communicate with a computer over GPIB or RS-232 interface. Only one interface can be used at a time. When shipped from the factory, the GPIB interface is selected and its address is set to "9".

Note The RS-232 interface can be configured and used only in SCPI mode.

GPIB Interface

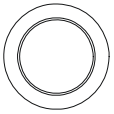
Each device on the GPIB interface must have a unique address.

- When shipped from the factory, the GPIB interface is selected and its address is set to "9". The GPIB address of the instrument can be set to any value between 0 and 30.
- The GPIB address is stored in non-volatile memory, and does not change when the instrument is turned off or reset.
- Switching between SCPI mode and 3488A mode causes the 3499A/B/C to select the GPIB interface and its address setting.

To set the GPIB interface:

1. Press the **Menu** key. The **CONFIG** annunciator lights up and the first level menu is shown.

CARD PAIR



2. Turn the knob to select "INTERFACE" in the menu.

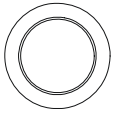
INTERFACE

3. Press **Enter** to show the second level menu The active interface is shown. If necessary, turn the knob until "GPIB/488" is displayed.

GPIB/488

4. Press **Enter** to select the interface and show the first parameter.

ADDRESS 09



5. Turn the knob to set GPIB address (i.e., 07). Valid addresses range from 00 to 30.

ADDRESS 07

6. Press **Enter** to show the second parameter.

SRQ ON

7. Press **Enter** to enable the instrument to assert the SRQ line when powered up. If the computer is so configured, this can be used to interrupt the system computer.

   To disable this feature, turn the knob to select "SRQ OFF" and press **Enter**. The instrument returns to the first level of the menu.

8. Press **Menu** again to exit the menu.The **CONFIG** annunciator turns off.

2

RS-232 Interface

RS-232 interface can be selected and its baud rate, parity, and flow control mode can be configured from the front-panel.

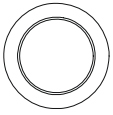
- **Baud Rate:** The baud rate can be set to one of the following: 2400, 4800, 9600, 19200, 38400, or 57600. The factory default setting is 9600.
- **Parity** and **Data Bits:** The parity and data bits can be set to one of the following: None, 8 bits; Even, 7 bits; or Odd, 7 bits. The factory default setting is None, 8 bits.
- **Flow Control:** The flow control can be set to one of the following: None (factory default setting), XON/XOFF, DTR/DSR, RTS/CTS.
  - **None:** In this mode, data is sent and received over the interface without any flow control. When using this method, use a slower baud rate (< 9600 baud) and avoid sending more than 128 characters without stopping or reading a response.
  - **XON/XOFF:** This mode uses special characters embedded in the data stream to control the flow. If the instrument is addressed to send data, it continues sending data until the "XOFF" (13_h) character is received. When the "XON" character (11_h) is received, the instrument resumes sending data.
  - **DTR/DSR:** In this mode, the instrument monitors the state of the DSR (data set ready) line on the RS-232 connector. When the line goes true, the instrument sends data over the interface. When the line goes false, the instrument stops sending information (typically within six characters). The instrument sets the DTR line false when the input buffer is almost full (approximately 100 characters) and releases the line when space is available again.
  - **RTS/CTS:** This mode operates the same as the DTR/DSR mode but uses the RTS (request to send) and CTS (clear to send) lines on the RS-232 connector instead. When the CTS line goes true, the instrument sends data over the interface. When the line goes false, the instrument stops sending information (typically within six characters). The instrument sets the RTS line false when the input buffer is almost full (approximately 100 characters) and releases the line when space is available again.
- Changing the instrument system mode (SCPI or 3488) causes the instrument to select the GPIB interface and its address setting.

To set the RS-232 interface:

Menu

1. Press the **Menu** key. The **CONFIG** annunciator lights up and the first level menu is shown.

CARD PAIR



2. Turn the knob to select "INTERFACE" in the menu.

INTERFACE

Enter

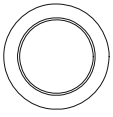
3. Press **Enter** to show the second level menu The active interface is shown. If necessary, turn the knob until "RS-232" is displayed.

RS-232

Enter

4. Press **Enter** to select the interface and show the first parameter.

9600 BAUD



5. Turn the knob until the desired baud rate is displayed.

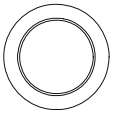
19200 BAUD

Enter

6. Press **Enter** to select the baud rate and show the second parameter.

NONE; 8 BITS

2



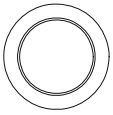
7. Turn the knob until the desired parity and data bits (default: NONE, 8 BITS) is displayed.

EVEN;7 BITS

Enter

8. Press **Enter** to select the parity and data bits and show the fourth parameter.

FLOW NONE



9. Turn the knob until the desired mode is displayed.

FLOW RTS/CTS

Enter

10. Press **Enter** to select the parity and data bits and return to the first level of the Menu menu.

INTERFACE

Menu

11. Press **Menu** again to exit the menu. The **CONFIG** annunciator turns off.

2

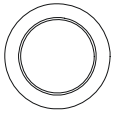
To Perform a Self-test

The self-test feature of the instrument provides you with a method of verifying proper instrument operation.

Menu

1. Press the **Menu** key. The **CONFIG** annunciator lights up and the first level menu is shown.

   CARD PAIR



2. Turn the knob to select “SELFTEST”.

   SELFTEST

Enter

3. Press **Enter**. The self test will begin. The display will briefly show a “starburst” pattern (all display segments lit). Following the pattern, the display indicates:

   TEST. . .

   while the internal tests are being performed. The self-test takes several seconds to complete.

   If the self-test is successful, “PASSED” will be displayed. Otherwise, the reason of the failure will be displayed. For details on self-test failures, refer to “Self-Test Errors” on page 172.

   PASSED

Enter

4. Press **Enter** to return to the first level of the menu.

   SELFTEST

Menu

5. Press **Menu** again to exit the Menu menu, the **CONFIG** annunciator turns off.

2

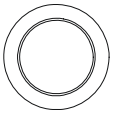
To Query the Firmware Revision

Perform the following procedure to query the 3499A/B/C firmware and revision. For a description of the firmware and hardware revisions, see "Firmware and Control Module Description" on page 59.

Menu

1. Press the **Menu** key. The **CONFIG** annunciator lights up and the first level menu is shown.

   CARD PAIR



2. Turn the knob to select "REVISION INFO".

   REVISION INFO

Enter

3. Press **Enter**. The system firmware revision number will be displayed.

   REVISION 4.0 2.0

Enter

4. Press **Enter** to return to the first level of the Menu menu.

   REVISION INFO

Menu

5. Press **Menu** again to exit the Menu menu, the **CONFIG** annunciator turns off.

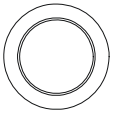
To Query the Serial Number

Perform the following procedure to query the 3499A/B/C serial number.

Menu

1. Press the **Menu** key. The **CONFIG** annunciator lights up and the first level menu is shown.

CARD PAIR



1. Turn the knob to select “SERIAL NO”.

SERIAL NO

Enter

2. Press **Enter**. The Agilent 3499A/B/C serial number is displayed.

MY12345678

Enter

3. Press **Enter** again to return to the first level of the Menu menu.

SERIAL NO

Menu

4. Press **Menu** again to exit the Menu menu, the **CONFIG** annunciator turns off.

2

Local/Remote Control

The instrument operates in two data entry modes, *local* and *remote*. In local mode, all keys on the front panel are fully functional. In *remote* mode, some front panel keys are locked (exception are: **Local, Mon, View, Enter,** the arrow keys, and the knob).

The instrument will enter the remote state upon receipt of any command over the remote interface. The **RMT** annunciator lights.

Shift

You can regain control of the front panel keys when the instrument is in remote by pressing the **Shift** (Local) key. The **RMT** annunciator turns off and the instrument return to local mode.

Note

If the front panel keys are locked through either the SYSTem:RWLock command on the RS-232 interface or a LOCAL LOCKOUT command on the GPIB interface, the local key will not function. You can restore the front panel operation by cycling power the instrument or by sending a SYSTem:LOCal command on the RS-232 interface, or a LOCAL command on the GPIB interface.

System Overview

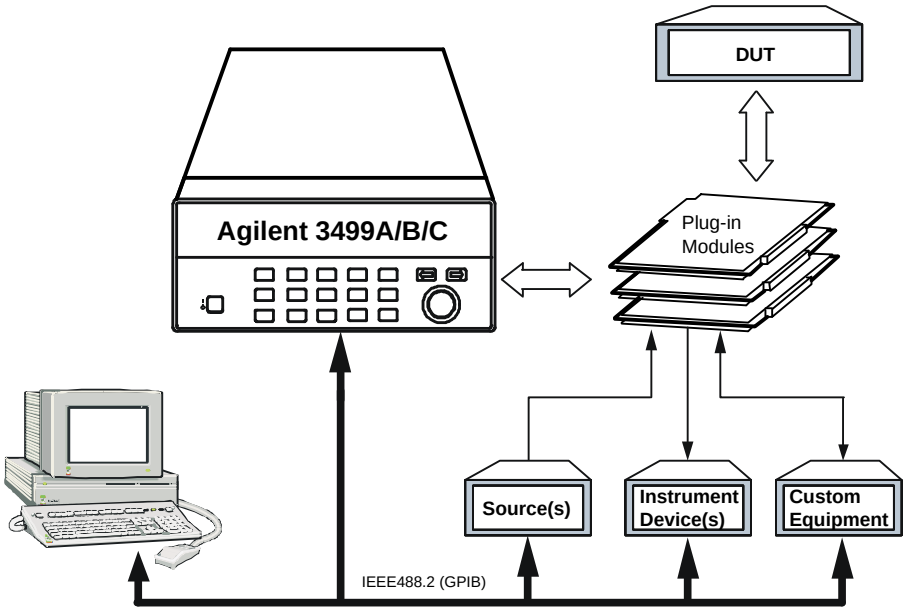
System Overview

An Agilent 3499A/B/C Switch/Control System is composed of a mainframe and a set of Plug-in modules. This chapter provides a typical configuration of a test system using the 3499A/B/C for switching and control, followed by a description of the three mainframes and all the Plug-in modules. The following sections are included in this chapter:

- Agilent 3499A/B/C Switch/Control System, on page 57
- Mainframes Overview, on page 58
- Firmware and Control Module Description, on page 59
- Plug-in Modules Overview, on page 61
- Channel and Slot Addressing, on page 70
- Factory Default and Reset States, on page 74

Agilent 3499A/B/C Switch/Control System

The Agilent 3499A/B/C Switch/Control System provides high density and high speed switching for routing test signals to and from your DUTs (devices under test) and test instruments such as external DMMs, scopes, counters, power supplies, etc. Whether you are involved in a large production test system or a small R&D bench top system, the Agilent 3499A/B/C provides an ideal combination of price/performance solution. With a wide variety of available plug-in modules, you can configure your test system much more easily and flexibly. The figure below shows the typical configuration of a test system.



A Typical Test System

3

Mainframes Overview

Three mainframes are available:

	Slots Available	Rack Width
3499A	5	full width
3499B	2	half width
3499C	9[1]	full width

[1] The 3499C is designed to accommodate multiple width plug-in modules and has 9 logical slots but 14 mechanical slots. Slots 1 through 6 are 1-slot wide, slot 7 is 2-slots wide, and slots 8 and 9 are each 3-slots wide. See the figure on page 7 for more information.

All mainframes can be either operated from the front-panel or programed over a remote interface (GPIB or RS-232).

The mainframes can be operated in either of two system modes: SCPI mode or 3488A mode. The SCPI mode allows the full realization of performance potentials and advanced features, such as parallel operation of multiple relays on multiple modules. The 3488A mode is included for backward compatibility with the legacy Agilent 3488A system. This manual documents the SCPI mode of operation.

For information about the 3488 programming mode please visit www.agilent.com.

Firmware and Control Module Description

The Agilent 3499A/B/C and this manual support two versions of the Agilent 3499A/B/C control module and four versions of firmware.

Firmware revisions and control module versions can be queried either by front-panel operation or using the remote interface. See page 52 for a procedure to read the revision from the front-panel or page 153 for remote interface operation.

From the front-panel:

Control Module Revision	Firmware Revision	Typical Display
1.0	1.0	REVISION 1.0
1.0	2.0	REVISION 2.0
1.0	3.0	REVISION 3.0
2.0	4.0	REV 4.0 2.0

From the remote interface, in response to the *IDN? query, one of two typical strings is returned:

"Agilent Technologies, 3499, cnxxxxxx, 3.0"

"Agilent Technologies, 3499, myxxxxxx, 4.0 2.0"

In these strings, cnxxxxxx or myxxxxxx is the instrument serial number. Note that the control module revision is not returned for revision 1.0 control modules.

The table on the next page lists the differences between firmware and control module revisions.

Firmware Version	Control Module Version	State Storage	Plug-in module Support	Programming Modes	Firmware Upgrade Needed?
1.0	1.0	Stored setups are cleared if power is cycled.	Must upgrade hardware and firmware.	Not Applicable	YES
2.0	1.0	Stored setups are cleared if power is cycled.	Supports all modules except: N2272A N2276A/B N2282A	Firmware Version 2.0 allows programming in both SCPI Mode and 3488A Mode.	Upgrade to Firmware Revision 3.0 ONLY if using N2272A, N2276A/B, or N2282A.
3.0	1.0	Stored setups are cleared if power is cycled.	*SCPI Mode* supports all modules. *3488A Mode* supports all modules except: N2272A, N2276A/B, or N2282A.	Firmware Version 3.0 limits programming to either SCPI Mode or 3488A Mode (not both)	Upgrade to firmware revision 4.0 ONLY if control board revision is upgraded to 2.0.
4.0[1]	2.0	Stored setups are saved. Instrument can be programmed to power up in a set state.	*SCPI Mode*: supports all modules. *3488A Mode* supports all modules except: N2272A, N2276A/B, or N2282A.	Firmware Version 4.0 allows programming in both SCPI Mode and 3488A Mode.	NO

[1] Upgrading to firmware revision 4.0 requires the control module be upgraded to revision 2.0. Control module revision 1.0 **does not** support firmware revision 4.0.

Plug-in Modules Overview

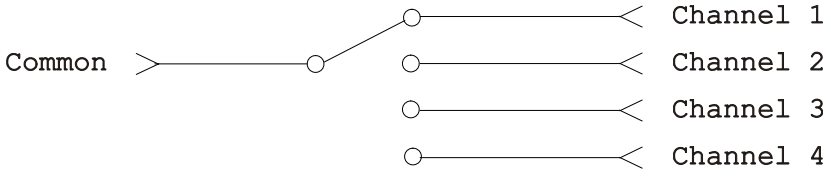
The Agilent 3499A/B/C mainframes support multiple Plug-in modules, including all the existing 3488A modules (4447XX modules), as well as several new ones (N22XXX modules). Based on their functions, the modules can be divided into five classes:

- Multiplexer (MUX) modules
- General Purpose Relay (GP) modules
- Matrix modules
- Digital I/O (DIO) modules
- Multifunction modules
- Optical Modules

Note Refer to the "Plug-in Modules" chapter on page 173 for the details of the individual Plug-in modules.

MUX Modules

A MUX (multiplexer) module switches one signal to multiple DUTs (devices under test), or multiple signals to one device, one at a time. Example applications include capacitor leakage, connector/switch contact, and insulation resistance test systems. To expand switching capacity or build special configurations, the multiplexer switching modules can also be used with matrix or other switching modules. The figure below shows a simple 1 x 4 Multiplexer.



Simple Multiplexer Switching

Multiplexers are available in several types:

- *One-Wire (Single-Ended) Multiplexer* for common LO measurements
- *Two-Wire Multiplexer* for floating measurements
- *Four-Wire Multiplexer* for resistance and RTD measurements
- *Very High Frequency (VHF) / Microwave Multiplexer* for switching frequencies up to microwave (26.5 GHz).

The table below lists the available MUX modules.

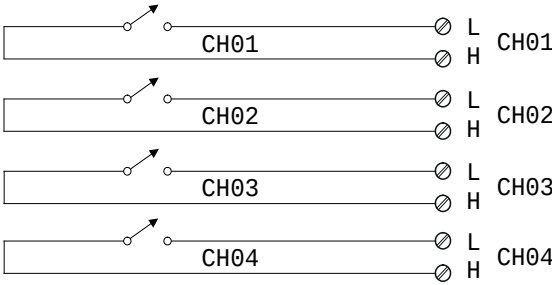
Model Number	Module Name	Mainframe Slots Required	Relay Type	Description
N2260A	40-Channel MUX Module	1	Latching	Primarily a 40-channel 2-wire multiplexer, switches both HI and LO inputs (200 V, 1 A) with DPST relays. It can be configured as an 80-channel 1-wire, two independent 20-channel 2-wire or a 20-channel 4-wire MUX module.
N2266A	40-Channel MUX Module	1	Reed non-latching	Primarily a 40-channel 2-wire multiplexer. In SCPI mode it can be configured as an 80-channel 1-wire, two independent 20-channel 2-wire or a 20-channel 4-wire MUX module.

Caution In order to stay within the 20W power limit set for convection cooling, no more than three (3) N2266A 40-Channel MUX Modules should be installed in an Agilent 3499A mainframe; the remaining two slots must remain empty. Other module combinations are acceptable; for example, two N2266A MUX modules plus any combination of other Agilent modules is permissible. This limitation does not apply to the 3499B or 3499C mainframes.

Model Number	Module Name	Mainframe Slots Required	Relay Type	Description
N2268A	50Ω 3.0 GHz Dual 4-to-1 MUX Module	1	Latching	Consists of two independent 1-to-4 MUX switches which can switch up to 30VDC or peak AC from DC to 3.0 GHz.
N2270A	10-Channel High Voltage MUX Module	2	Non-latching	10-channel 2-wire High Voltage MUX module with maximum switching voltage 1000Vpk, maximum switching power 10W.
N2272A	1 GHz RF 1-to-9 MUX Module	1	Latching	1 GHz RF 1-to-9 MUX module which can be used in RF testing and measuring.
N2276A/B	Dual 1-to-6(4) Microwave MUX/ Attenuator Module	3	Non-latching	3-slot width Dual 1-to-6(4) Microwave MUX/Attenuator module with optional Microwave switch blocks and programmable attenuator blocks.
44470A/D	10/20-Channel MUX Module	1	Latching	The 10/20 DPST (Double-pole Single-throw) relays switch both HI and LO inputs up to 250V, 2A with low differential offsets for accurate measurements.
44472A	Dual 4-Channel VHF Switch Module	1	Latching	The two independent groups of bidirectional 1x4 switches with 50Ω characteristic impedance can be used for signals from DC to 300 MHz.
44478A/B	50Ω/75Ω 1.3 GHz Multiplexer	1	Latching	The two independent groups of bidirectional 1x4 switches with 50Ω/75Ω characteristic impedance can be used for signals from DC to 1.3 GHz.

GP Modules

The GP (General Purpose) relay modules often consist of independent latching or non-latching relays. They are useful for creating additional isolation between circuits, providing safety interlocks, actuating other relays or circuits, or building special topologies such as binary ladders and tree structures. A simple 4-channel SPST (Single-pole Single-throw) GP switch is shown below.



A Simple General Purpose Switch

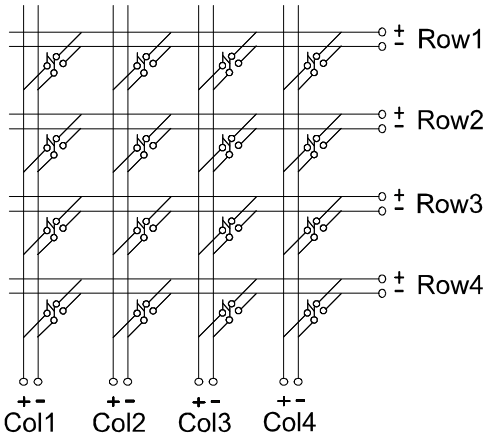
The table below lists the available GP relay modules.

Model Number	Module Name	Mainframe Slots Required	Relay Type	Description
N2261A	40-Channel GP Relay Module	1	Latching	The 40 independent SPST relays provide quality connections for low level signals. Can also switch signals up to 200V, 1A.
N2267A	8-Channel High Current GP Module	1	Non-latching	An 8-channel High Current GP module which can switch up to 8A 250VAC or 5A 30VDC, with decreasing current to 1A at 125VDC.
44471A	10-Channel GP Relay Module	1	Latching	The 10 independent SPST (Single-pole Single-throw) relays provide quality connections for low level signals. Can also switch signals up to 250V, 2A.

Model Number	Module Name	Mainframe Slots Required	Relay Type	Description
44471D	20-Channel GP Relay Module	1	Latching	The 20 independent SPST (Single-pole Single-throw) relays provide quality connections for low level signals. Can also switch signals up to 250V, 1A.
44475A	Breadboard Module	1	NA	Use the breadboard for custom circuits and special purpose functions in your test system.
44476A	3-Channel 18 GHz Switch Module	1	Latching	The 3 independent 50Ω SPDT (Single-pole Double-throw) coaxial switches with SMA connectors provide high isolation, low insertion loss, and low VSWR for switching signals up to 18 GHz.
44476B	2-Channel Microwave Switch Module	1	NA	Similar to the 44476A but does not have the coaxial switches installed. A variety of coaxial switches can be mounted onto the module to provide 3-, 4-, or 5-port switching up to 26.5 GHz.
44477A	7-Channel Form-C Relay Module	1	Latching	7 independent, break-before-make, SPDT Form-C relays for general purpose switching and control of external devices up to 250V, 2A.

Matrix Modules

A matrix switch is the most versatile type of system switching. Any input can be connected to any output, individually or in combination. This helps minimize the need for complex wiring, and can simplify the DUT interface. In addition, a matrix module can be used in conjunction with other modules to provide a wide variety of switching combinations. A matrix is arranged in rows and columns and a simple 4 x 4 matrix switch is shown below.



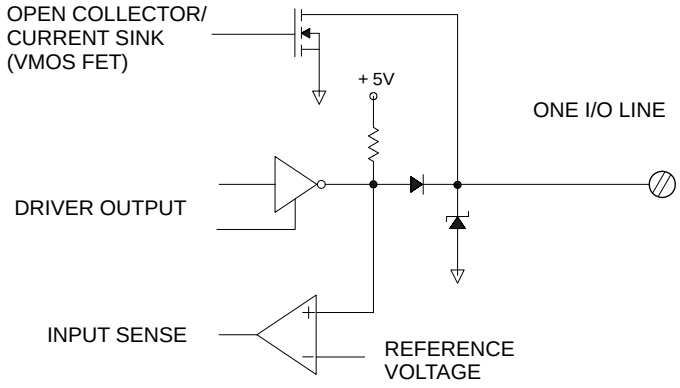
Matrix Switching

The table below lists the available matrix modules.

Model Number	Module Name	Mainframe Slots Required	Relay Type	Description
N2262A	4 x 8 Matrix Module	1	Latching	Each crosspoint or node of the 4 x 8 matrix module uses a DPST (Double-pole Single-throw) relay to switch two wires (Hi & Lo) for signals up to 200V, 1A.
44473A	4 x 4 Matrix Module	1	Latching	Each crosspoint or node of the 4 x 4 matrix module uses a DPST (Double-pole Single-throw) relay to switch two wires (Hi & Lo) for signals up to 250V, 2A.

Digital I/O Modules

The digital I/O modules provide high-density digital input/output capabilities in an easy-to-control form. The independent TTL-compatible inputs and outputs make it well-suited for monitoring and controlling devices compactly and cost-effectively. Typically, the digital outputs are used to provide drive for relatively high current devices such as solenoids, relays and small motors. The digital inputs are used to monitor devices such as micro-switches. A simplified schematic of a single digital input and output line is shown below.



A Simple Digital I/O Circuit

The table below lists the available digital I/O modules.

Model Number	Module Name	Mainframe Slots Required	Descriptions
N2263A	32-Bit Digital I/O Module	1	The module offers 32-bidirectional I/O lines and three handshake lines for sensing and control of external devices up to 42 V, 600 mA. All lines are TTL-compatible.
44474A	16-Bit Digital I/O Module	1	The module offers 16-bidirectional I/O lines and four handshake lines for sensing and control of external devices up to 30 V, 125 mA. All lines are TTL-compatible.

Multifunction Modules

A multifunction module combines two or more functions such as MUX, GP, Matrix, Digital I/O or DAC onto a single module, making it possible to implement a complicated switching application with fewer modules. Therefore, the cost is reduced by minimizing the number of mainframes and modules required.

Each separate function on a multifunction module can be operated independently. For example, an Agilent N2265A can be used as both a 4 x 4 matrix module and a 16-bit digital I/O module.

The table below lists the available multifunction modules.

Model Number	Module Name	Mainframe Slots Required	Relay Type	Description
N2264A	12-Channel GP + 3-Channel High-current GP + 16-Bit Digital I/O Module	1	Non-latching	The module provides 12-channel SPST (Single-pole Single-throw) GP relays for signals up to 200 V, 1 A, 3-channel high-current GP relays for signals up to 125 V, 5 A, and 16-bit digital I/O for sensing and control of external devices up to 42 V, 600 mA.
N2265A	4 x 4 Matrix + 16-Bit Digital I/O Module	1	Latching	The module provides 4 x 4 2-wire matrix for signals up to 200V, 1A, and 16-bit digital I/O for sensing and control of external devices up to 42 V, 600 mA.

Optical Modules

The Agilent N2280A, N2281A and N2282A are optical switch modules. The table below lists the information about these three optical modules.

Model Number	Module Name	Mainframe Slots Required	Relay Type	Description
N2280A	Optical Switch Quad 1-to-2 MUX Module	2	Non-latching	Four 1-to-2 Optical Switches
N2281A	Optical Switch Dual 1-to-4 MUX Module	2	Non-latching	Two 1-to-4 Optical Switches
N2282A	Optical Switch 1-to-8 MUX Module	2	Latching	One 1-to-8 Optical Switch

3

Channel and Slot Addressing

A channel refers to an individual relay on a switching module, or an individual bit/port on a digital I/O module. The channel address is in the form of *snn*, where *s* represents slot number and *nn* represents a channel number.

For all mainframes, slot 0 refers to the 3499A/B/C control board. Valid slot numbers are:

3499A	slots 0 through 5
3499B	slots 0 through 2
3499C	slots 0 through 9

The channel number, *nn*, is plug-in module dependent. Detailed information about channel numbers of individual plug-in modules is given below and on the following pages.

Plug-in Module	**Channel Addressing *(snn)*** ***s* = Slot Number; *nn* = Channel Number**
N2260A 40-Channel MUX Module[a]	**1-Wire Mode:** *s00, s01... s78, s79*[b] **2-Wire Mode:** *s00, s01...s38, s39* **Dual 2-Wire Mode:** *s00, s01...s38, s39* **4-Wire Mode:** *s00, s01...s18, s19*[c]
N2261A 40-Channel GP Relay Module	*s00, s01, s02, s03... s37, s38, s39*
N2262A 4X8 Matrix Module	Row 0, 1, 2, 3; Column 0, 1, 2, 3... 6, 7 (*s00, s01, s02... s07; s10, s11, s12... s17; s20, s21, s22... s27; s30, s31, s32... s37*)[d]

a. The N2260A and N2266A can be used as an 80-channel 1-wire MUX module, a 40-channel 2-wire MUX module, two 20-channel 2-wire MUX modules, or a 20-channel 4-wire MUX module.

b. The Low (L) terminals of the 40 2-wire channels form the first 40 1-wire channels (Channels 00-39), and the High (H) terminals of the 40 2-wire channels form the second 40 1-wire channels (Channels 40-79).

c. The first channels (CH00 & CH20) of either banks (BANK 0 and BANK 1) form Channel 00, the second channels (CH01 & CH21) of either banks form Channel 01, and so on.

d. A channel number on a matrix module is formed in Slot-Row-Column format, i.e., channel address s23 means row 2, column 3 in Slot s.

Plug-in Module	**Channel Addressing *(snn)*** ***s* = Slot Number; *nn* = Channel Number**
N2263A 32-Bit Digital I/O Module	**Individual Bits:** *s00, s01, s02... s30, s31* **8-Bit Ports:** *s00, s01, s02, s03* **16-Bit Ports:** *s00, s02* **32-Bit Port:** *s00*
N2264A 12-Channel GP Relay + 3-Channel High-current GP Relays + 16-Bit Digital I/O Module	**12 GP Relays:** *s00, s01, s02... s10, s11* **3 High-current GP Relays:** *s20, s21, s22* **16-Bit Digital I/O:** **Individual Bits:** *s30, s31, s32... s44, s45* **8-Bit Ports:** *s30, s31* **16-Bit Port:** *s30*
N2265A 4x4 Matrix + 16-Bit Digital I/O Module	**4x4 Matrix:** Row 0, 1, 2, 3; Column 0, 1, 2, 3 (*s00, s01, s02, s03; s10, s11, s12, s13; s20, s21, s22, s23; s30, s31, s32, s33*)[a] **16-Bit Digital I/O:** **Individual Bits:** *s40, s41, s42... s54, s55* **8-Bit Ports:** *s40, s41* **16-Bit Port:** *s40*
N2266A 40-Channel MUX Module[b]	**1-Wire Mode:** *s00, s01... s78, s79*[c] **2-Wire Mode:** *s00, s01...s38, s39* **Dual 2-Wire Mode:** *s00, s01...s38, s39* **4-Wire Mode:** *s00, s01...s18, s19*[d]
N2267A 8-Channel High Current GP Module	*s00, s01, s02... s07*
N2268A 50Ω 3.0 GHz Dual 4-to-1 MUX Module	*s00, s01, s02, s03; s10, s11, s12, s13*

a. A channel number on a matrix module is formed in Slot-Row-Column format, i.e., channel address s23 means row 2, column 3 in Slot s.

b. The N2260A and N2266A can be used as an 80-channel 1-wire MUX module, a 40-channel 2-wire MUX module, two 20-channel 2-wire MUX modules, or a 20-channel 4-wire MUX module.

c. The Low (L) terminals of the 40 2-wire channels form the first 40 1-wire channels (Channels 00-39), and the High (H) terminals of the 40 2-wire channels form the second 40 1-wire channels (Channels 40-79).

d. The first channels (CH00 & CH20) of either banks (BANK 0 and BANK 1) form Channel 00, the second channels (CH01 & CH21) of either banks form Channel 01, and so on.

Plug-in Module	**Channel Addressing *(snn)*** ***s* = Slot Number; *nn* = Channel Number**
N2270A 10-Channel HIgh Voltage MUX Module	*s00, s01, s02... s07*
N2272A 1 GHz RF 1-to-9 MUX Module	*s00, s01, s02... s07*
N2276A/B Dual 1-to-6 (4) Microwave MUX/ Attenuator Module	**Two 1-to-4(6) Microwave Switch:** *s00, s01, s02, s03*(, *s04, s05*); *s10, s11, s12, s13*(, *s14, s15*) **Two Attenuators:** *s20; s30*
N2280A Optical Switch Quad 1-to-2 MUX Module	*s00, s01; s10, s11; s20, s21; s30, s31*
N2281A Optical Switch Dual 1-to-4 MUX Module	*s00, s01, s02, s03;s10, s11, s12, s13*
N2282A Optical Switch 1-to-8 MUX Module	*s00, s01, s02... s07*
4-Bit Built-in Digital I/O (slot 0 control module)	**Individual Bits:** *091, 092, 093, 094* **4-Bit Port:** *090*
44470A 10-Channel MUX Module	*s00, s01, s02, s03... s08, s09*
44470D 20-Channel MUX Module	*s00, s01, s02, s03... s18, s19*
44471A 10-Channel GP Relay Module	*s00, s01, s02, s03... s08, s09*
44471D 20-Channel GP Relay Module	*s00, s01, s02, s03... s18, s19*
44472A Dual 4-Channel VHF Module	**Group 0:** *s00, s01, s02, s03* **Group 1:** *s10, s11, s12, s13*

Plug-in Module	**Channel Addressing *(snn)*** ***s* = Slot Number; *nn* = Channel Number**
44473A 4x4 Matrix Module	Row: 0, 1, 2, 3; Column: 0, 1, 2, 3 (*s00, s01, s02, s03; s10, s11, s12, s13; s20, s21, s22, s23; s30, s31, s32, s33)*[a]
44474A 16-Bit Digital I/O Module	**Individual Bits:** *s00, s01, s02... s14, s15* **8-Bit Ports:** *s00, s01* **16-Bit Port:** *s00*
44475A Breadboard Module	N/A
44476A 3-Channel 13 GHz Microwave Switch Module	*s00, s01, s02*
44476B 2-Channel 26 GHz Microwave Switch Module	*s00, s01*
44477A 7-Channel Form-C Relay Module	*s00, s01, s02, s03, s04, s05, s06*
44478A 50 Ω 1.3 GHz MUX Module	**Group 0:** *s00, s01, s02, s03* **Group 1:** *s10, s11, s12, s13*
44478B 75 Ω 1.3 GHz MUX Module	**Group 0:** *s00, s01, s02, s03* **Group 1:** *s10, s11, s12, s13*

a. A channel number on a matrix module is formed in Slot-Row-Column format, i.e., channel address s23 means row 2, column 3 in Slot s.

Factory Default and Reset States

The table on the next page shows the settings of the instrument after a reset (in SCPI mode) as well as the default settings when the instrument is shipped from the factory. (A table showing the 3488 reset settings is given on page 76.)

- You can reset the instrument either by pressing **Shift + Card Reset** on the front-panel, or with a `*RST` command over the remote interface.
- If a module is accidentally removed or installed while the instrument power is on, the instrument will preform a reset.

SCPI Mode Defaults

Item		Factory Default	Reset
Interface	GPIB/488	GPIB (Address 9)	Keep current setting[a]
	RS-232		Keep current setting[a]
System Mode	SCPI Mode	SCPI Mode	Keep current setting
	3488A Mode		Keep current setting
System Related	Display State	On	On
	Stored State	Empty	Keep current setting
	Error Queue	Empty	Not cleared
Module Related	Switching Channels	Open	Open
	Digital I/O Ports	Input	Input
	Card Pair	None	None
Scan Related	Scanning	None	Stop scan in progress
	Scan List	Empty	Empty
	ARM SOURce	IMMediate	IMMediate
	ARM TIMer (seconds)	0	0
	Arm Count	1	1
	TRIGger SOURce	IMMediate	IMMediate
	TRIGger TIMer (seconds)	0	0
	Channel Delay (seconds)	0	0
	Trigger Out Pulse	Disabled	Disabled

a. Current setting includes the selection of an interface, as well as the settings for the interface.

3

3488 Mode Defaults

Item		Factory Default	Reset
Interface	GPIB/488	GPIB (Address 9)	Keep current setting[a]
	RS-232[b]		Keep current setting
System Mode	SCPI Mode	SCPI Mode	Keep current setting
	3488A Mode		Keep current setting
System-Related	Display State	On	On
	Stored State	Empty	Keep current setting
	Error Queue	Empty	Cleared
Module-Related	Switching Channels	Open	Open
	Digital I/O Ports	Input	Input
	Card Pair	None	None
Scan-Related	Scanning	None	Stop scan in progress
	Scan List	Empty	Empty
	Channel Delay (seconds)	0	0
	Trigger Out Pulse	Disabled	Disabled

a. Current setting includes the selection of the GPIB interface and its address setting.
b. RS-232 interface CANNOT be used in 3488A mode.

Features and Functions

Features and Functions

This chapter provides details about particular functions and features of the Agilent 3499A/B/C Switch/Control System. The sections in this chapter describe the features using both the front-panel and the remote interface using SCPI commands. The examples in this chapter are general. For specific procedures using the front panel refer to Chapter 2. For SCPI command information refer to Chapter 5. The following sections are included in this chapter:

- Monitoring a Channel or a Slot, on page 80
- Switching a Relay Channel, on page 82
- Configuring a Multiplexer Module, on page 83
- Parallel Switching, on page 84
- Scanning, on page 85
- Digital I/O Operation, on page 95
- State Storage, on page 106
- Error Conditions, on page 108
- Self-Test, on page 109
- Display Control, on page 110
- Relay Cycle Counts, on page 111
- To Select the System Mode, on page 112

The following conventions are used for the front-panel operation.

- All keys on the front-panel keyboard are expressed in bold font and normally associated with a “press”. For example, press **Mon**.
- All the front-panel display annunciators are expressed in bold font followed by an “annunciator”. For example, **MON** annunciator.
- The information shown on the front-panel display is enclosed within a pair of quotation marks.
- **Shift + Recall**[1] indicates the sequential operation: first press **Shift**, then press **Recall**.

[1] Also applicable to keys **Card Reset**, **Scan**, and **S.List**.

SCPI Language Conventions

Throughout this manual, the following conventions are used for SCPI command syntax for remote interface programming.

- Square brackets (**[ ]**) indicate optional keywords or parameters.
- Braces (**{ }**) enclose parameter choices within a command string.
- Angle brackets (**< >**) enclose parameters for which you must specify a value.
- A vertical bar (**|**) separates multiple parameters.

Rules for Using a Channel or Scan List

Many of the SCPI commands include a channel list or scan list parameter which allows you to specify one or more channels. The channel number has the form (@*snn*), where *s* is the slot number and *nn* is the channel number. You can specify a slot, a single channel, multiple channels, or a range of channels as described below.

- The following command closes a single channel (channel 11) on the module installed in slot 1:

```
ROUT:CLOS (@111)
```

- The following command closes multiple channels on modules in slots 1 and 2:

```
ROUT:CLOS (@111,112,203,204)
```

- The following command closes a range of channels. When you specify a range of channels, the range may contain invalid channels (they are ignored), but the first and last channel in the list must be valid.

```
ROUT:CLOS (@101:111)
```

- Additional information about channel and slot numbering is given on page 70.

Monitoring a Channel or a Slot

You may need to continuously monitor the current status of a particular switching channel, a digital I/O port, or an entire plug-in module. This is especially useful when developing and debugging remote interface commands or watching for an important signal.

- To monitor a channel or a port, specify the channel or port number. To monitor a plug-in module, specify the slot number. The displayed information is module type dependent as shown on the next page.
- *Front-Panel Operation: To s*elect a channel, a digital I/O port, or a slot, press **Mon**. The **MON** annunciator lights up. Press **Mon** again to exit this state.

MUX OPEN 101	*Monitor a switching channel 101.*
DIN 255 400	*Monitor a DIO Port 400.*
1:0, , , , , ,6, , ,9, 2	*Monitor a MUX or GP module.*
00: H255 L254. 4	*Monitor a DIO module.*

If only part of the channel status on the module can be displayed at one time, press **Enter** to display the next part.

- *Remote Interface Operation*: To enable the monitor mode, send a SCPI command similar to the ones shown below.

```
DIAG:MON 103          ! Monitor Channel 103.
DIAG:MON 400          ! Monitor a DIO Port 400.
DIAG:MON 2            ! Monitor the module in slot 2.
```

To query the slot or channel being monitored, send the following SCPI command.

```
DIAG:MON?             ! Returns the slot or channel
                        being monitored. Returns -1
                        if no channel or slot is
                        monitored.
```

Example MON Display	Description
1:0,,,,,6,,,9, 2	The display for a multiplexer or a GP relay module. This display indicates that the monitored module is in Slot 2 and channels 10, 16, and 19 are closed.
ROW 3:,1,,3,,,6,7 3 *0;,,3,COL 3, 3*	The display for a matrix module. The top display is the row information, indicating that the relays on Row 3, Columns 1, 3, 6 and 7 of the module (in Slot 3) are closed. The lower display is the column information, indicating that relays on column 3, row 0 and 3 are closed.
00:H255 L254. 4	The display for a digital I/O module. The first 2 digits on the left (“00” in this case) represents the “L” 8-bit port address. Adding one to this value, the “H” 8-bit port address is obtained. Data with a trailing decimal point indicates that the last operation on that port was a WRITE, data without a trailing decimal point indicates that the last operation on that port was a READ. This display shows that the data last read from Port 401 is 255 and the data last written to Port 400 was 254.
DIO 12 090 *DOUT 0 091*	The top display is for the built-in digital I/O Port *090* (controller module) and the data from the last operation. The lower display indicates that data last written to the bit channel 091 is 0.
ROW 0:,1,,3, 5 *00:H255 L254. 5*	For a multifunction module, the first function on the module is displayed, then the next. This display is an example of a multifunction module with matrix and DIO functions (in slot 5).

Switching a Relay Channel

Switch modules can be used to route signals to and from your test system. This is achieved by closing or opening the relay channels on these modules.

- From the front-panel, you can open or close one relay channel at a time. However, over the remote interface, multiple relay channels can be operated by a single command if a channel list is specified. In addition, these open or closed states can be stored, and a stored channel setup can be included in a scan list (see "State Storage" on page 106).
- Whenever a switch module is reset, all of the closed relay channels on the module will be opened.
- Whenever the instrument is turned on or reset, all of the closed relay channels in the instrument will be opened.
- *Front-Panel Operation:* Select a channel, press **Open** or **Close**.

  Select a slot, press and hold **Card Reset** to open all channels on the selected module.

  Press **Shift**, then press and hold **Card Reset** to open all channels in the instrument.
- *Remote Interface Operation:* The following commands open and close multiple channels on the modules in slots 1 and 2.

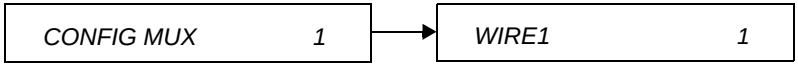
```
OPEN (@101,103:107,207)        ! Open multiple channels.
CLOS (@101,103:107,207)        ! Close multiple channels.
SYST:CPON 1                    ! Open all channels on the
                                 module in slot 1.
```

Note When an Agilent N2260A or N2266A is configured to the 1-wire mode, only one channel on the module can be closed at a time.

Configuring a Multiplexer Module

The Agilent N2260A and N2266A 40-Channel MUX modules can be flexibly configured.

- Configurations possible include:
  80-channel 1-wire
  40-channel 2-wire
  dual 20-channel 2-wire
  20-channel 4-wire
- At power on or after a reset, the MUX module will be configured as a 40-channel 2-wire MUX module (default setting).
- When configured to be an 80-channel 1-wire module, only one channel can be closed at a time.
- For more information about the N2260A see page 176.
  For more information about the N2266A see page 200.
- *Front-Panel Operation:* Select the slot in which an N2260A or N2266A is installed, press **Mode** (the **CONFIG** annunciator lights up). Select the desired function mode (i.e. 1-wire mode). Press **Enter**.



- *Remote Interface Operation:* A command parameter sets the operational mode of the multiplexer. This parameter can take one of the following values: `WIRE1`, `WIRE2`, `BIWIRE2`, or `WIRE4`.

```
[ROUTe]:FUNCtion 1, WIRE1        ! Configure the module in slot
                                   1 to be 1-wire mode.
```

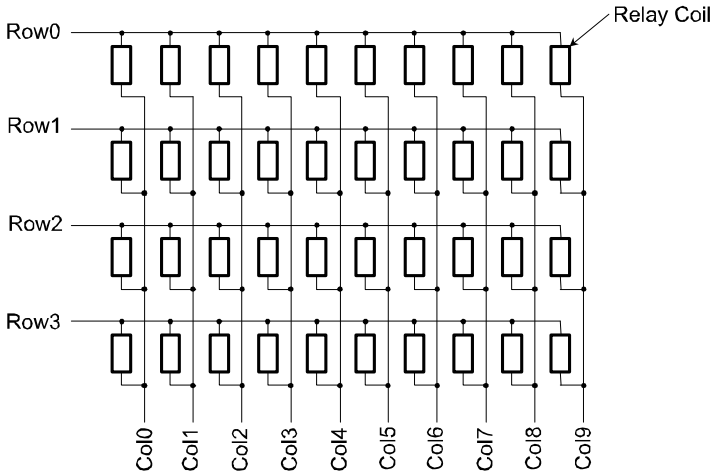
Parallel Switching

While traditional switch/control systems open/close relays in sequence, the 3499A/B/C uses an innovative parallel driving circuit to open/close switches simultaneously. The parallel operation of the 3499A/B/C significantly increases the test throughput of an automated test system.

The following plug-in module use parallel switching: N2260A, N2261A, N2264A, N2265A, and N2266A

For example, the 40, 2-wire relays on the N2260A can be separated into four banks: Bank 1 (CH00-09) through Bank 4 (CH30-39). The switches (up to 10) in the same bank can be closed simultaneously ('parallel switching').

Since a relay is controlled by the signal applied to it's coil, relay coils can be arranged in arrays to simplify the driver circuits. Coils aligned in the same row share a common row control signal, and coils aligned in the same column share a common column control signal. The figure below shows an array of coils with 4 rows and 10 columns. This is different from the wiring of the relay terminal from users' point of view. Relays can be connected and configured as MUX, GP, or MATRIX, while their driver circuits are similar.



The 3499A/B/C /C /C supports parallel operation of latching relays. Any relay in the same row can be opened or closed at the same time. Basically, the relays are switched row by row, or bank by bank.

Scanning

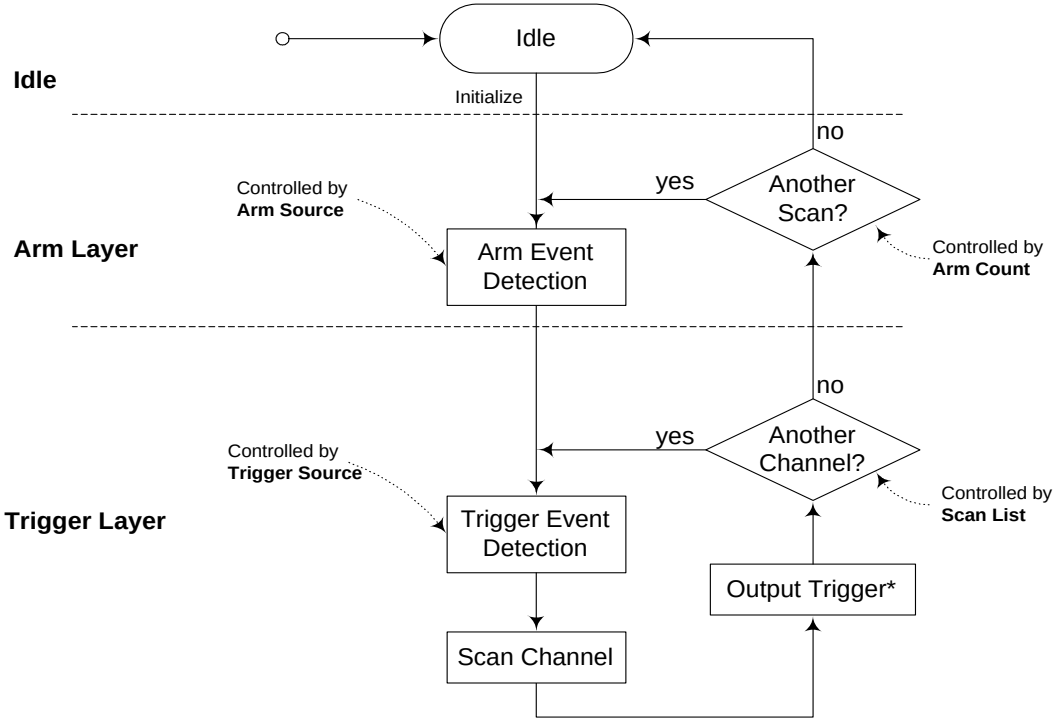
The Agilent 3499A/B/C can scan switching channels, digital I/O bit channels, and stored channel setups in a scan list. When a scan starts, the first channel in a scan list is closed. The channel is then opened and the next channel in the list is closed. This process repeats for all channels in the scan list. You can sweep through a scan list more than once. You can also synchronize scanned channel closures with external measurement devices.

Rules for Scanning

- A scan list must be specified before initiating a scan. One or more switching channels, digital I/O bit channels, and/or previously stored channel setups can be included in a scan list. The order of the channels in the scan list determines the order of the channels to be scanned.
- If any plug-in module is installed or removed while the instrument is operating, the instrument will automatically perform a reset and the current scan list is cleared.
- If a scan list contains a non-existing channel, the scan cannot be performed and an error will occur.
- If a scan list contains a channel on a digital I/O module that is not configured to handshake mode #1 or mode #2 (see page 98), the scan cannot be performed and an error will occur.
- If a mismatch between a stored channel setup in the scan list and the current hardware configuration is found, a scan cannot be performed and an error will occur. When a stored setup is included in the scan list, the stored setup is recalled and the next channel in the scan list is switched.
- When a scan is aborted, the channel last scanned before the interruption will remain closed. Aborting a scan does not affect the present scan configuration. A scan cannot resume from where it is interrupted. To initiate a new scan, the channels in the scan list will be scanned from the beginning of the scan list.
- A scan list may contain up to 200 entries.

The Scan Process

The figure below illustrates how a scan works.



* Note: The trigger out pulse will occur at the specified trig-out line only if you have configured to enable the slot to output.

The scan operation consists of two layers: *arm layer* and *trigger layer*. The instrument is considered to be in the *idle state* whenever it is not operating within either of these layers. When a scan is initiated, the instrument is taken out of the idle state and proceeds into the arm layer. When an arm source is detected, the instrument leaves the arm layer and proceeds to the trigger layer. In the trigger layer, for each detected trigger source, it advances one step in the scan list. After advancing through all the channels/bits in the scan list, and reaching the arm count, the scan is terminated and the instrument returns to the idle state.

Idle State

The instrument is considered to be in the *idle state* whenever it is not operating within any one of the layers. When the instrument is taken out of the idle state, the **SCAN** annunciator lights up and operation proceeds to the arm layer. From the remote interface, the `INITiate` command takes the instrument out of the idle state.

Arm Layer

The instrument requires an arm source to allow operation to proceed into the trigger layer. You can select the arm source from the following:

- **TIMER** — with timer arm source selected, the instrument will not proceed to the trigger layer unless the specified time interval has elapsed.
- **IMM** — with IMM (default) arm source selected, operation immediately proceeds to the trigger layer as soon as the instrument is taken out of the idle state.
- **BUS** — with bus arm source selected, the instrument will not proceed to the trigger layer unless a `GET` or a `*TRG` command is received, or **Step** on the front-panel is pressed.
- **EXT** — with external (EXT) arm source selected, the instrument will not proceed to the trigger layer unless an external trigger is received from the specified trigger-in line.
- **MIX** — with mix arm source selected, the instrument will not proceed to the trigger layer unless a BUS event or EXTernal event occurs.
- **HOLD** — with hold arm source selected, the instrument will wait for a `TRIGger:IMMediate` command before proceeding.

Trigger Layer

In trigger layer, the instrument requires a trigger source to open the previous channel and then close the next one listed in the scan list. You can use one of the following trigger sources:

- **TIMER** — with timer trigger source selected, the scan list advances when the specified time interval has elapsed.
- **IMM** — with IMM (default) trigger source selected, the scan list advances as soon as the previous channel is opened.
- **BUS** — with bus trigger source selected, the scan list advances when a `GET` or a `*TRG` command is received, or **Step** on the front-panel is pressed.
- **EXT** — with external (EXT) trigger source selected, the scan list advances when an external trigger is received from the specified trigger-in line.
- **MIX** — with mix trigger source selected, the scan list advances when a BUS event or EXTernal event occurs.
- **HOLD** — with hold trigger source selected, the scan list advances when a `TRIGger:IMMediate` command is received.

Creating a Scan List

Before initiating a scan, a scan list must be set up. The instrument scans the specified channels automatically in the same order of the scan list.

- The scan list is automatically cleared whenever the instrument is turned off or reset. You can also clear the scan list by pressing **Shift+S.List**.
- *Front-Panel Operation:* Press **S.List**, the **CONFIG** annunciator will light. The display will show "ADD TO SCAN". Press **Enter** to begin building the scan list. Select each desired channel and press **Enter** to add the channel to the scan list. As channels are added, an asterisk is shown in the display to indicate the channel is a part of the scan list.

ADD TO SCAN	*Press* **S.List**. *Press* **Enter**.
SELECT 101	*Select a channel to add.*
SELECT * 101	*Press* **Enter**.
SELECT 203	*Select the next channel to add.*

- *Remote Interface Operation:* You may use single channels, ranges of channel, or stored setups in the scan list. Set up a scan list with one command as follows:

```
[ROUTe]:SCAN (@100,104:109,411,1)
```

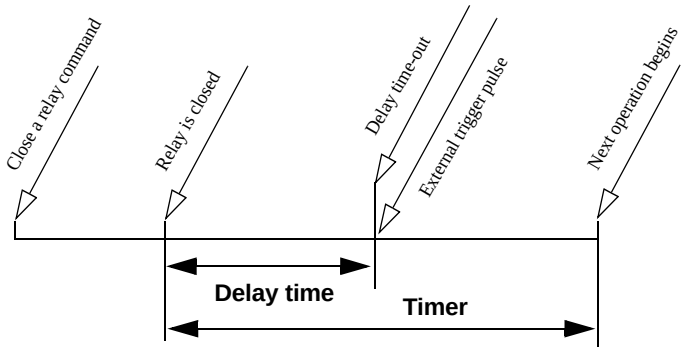
!Create scan list to include channel 100, channels 104 through 109, bit channel 411, and stored state 1.

Note Stored states may be used in scan lists. Stored states are discussed in more detail beginning on page 106.

Configuring a Scan

The scan procedure is controlled by specifying an arm source, a trigger source, and the number of sweeps (a sweep is one pass through the scan list). Delay times can also be configured.

- You can select any one of the six arm sources (listed on page 87) to control the onset of each sweep through the scan list. IMM (immediate) is the default arm source. If TIMer arm source is selected, the elapsed time can be set from 0 to 99999.999 seconds, with a 1 ms resolution.
- You can select any one of the six trigger sources (listed on page 88) to advance to the next channel in the scan list. IMM (immediate) is the default trigger source. If TIMer trigger source is selected, the elapsed time can be set from 0 to 99999.999 seconds, with a 1 ms resolution.
- You can specify the number of times (between 1 and 99999) the instrument is to sweep through the scan list. When the specified number is reached, the scan stops.
- You can specify a *delay time* (from 0 to 99999.999 seconds, with 1 ms resolution) between when a channel is closed and when the next operation begins (and, if configured, a *trigger out pulse* is sent). The delay time can be set individually for each channel in the scan list, or one delay can be set for all channels in the scan list. Note that, even if the trigger source is set to IMMediate, the scan list will not advance until the delay time is met.
- When you are using the trigger source TIMer and a delay time, they have a relationship as shown in the following diagram. If you set the delay time longer than the TIMer interval, the scan list will not advance until the delay time is met.



- *Front-Panel Operation:* Use the **S.List** menu to set the scan configuration as shown below.

CONFIG SCAN	*Press* **S.List**. *Turn knob. Press* **Enter**.
ARM: IMM	*Turn the knob to select the arm source Press* **Enter**.
COUNT: 00001	*Use arrow keys and knob to select the arm count. Press* **Enter**.
TRIG: IMM	*Turn the knob to select the trigger source. Press* **Enter**.
DELAY TIME	*Turn the knob to select DELAY TIME. Press* **Enter**.
SET ALL	*Turn the knob to select ALL channels or individual channels. Press* **Enter**.
00000.0000 SECS	*Use arrow keys and knob to select the delay time. Press* **Enter**.
3499	*Press* **S.List** *to exit the menu.*

If you select TIMER for either arm source or trigger source, an additional menu is shown that enables you to set the time in seconds.

- *Remote Interface Operation:* The following code sets the scan sweep to immediately start, the channel scan is advanced by the timer, and 10 sweeps of the scan list will occur. A 2 second delay is also set for channel 101.

```
ARM:SOURce IMMediate            ! Set arm source to IMM.
ARM:COUNt 10                    ! Set arm count to 10 times.
TRIGger:SOURce TIMer            ! Set trigger source to TIMer.
TRIGger:TIMer 5                 ! Set the trigger timer to 5
                                  seconds.
ROUTe:CHANnel:DELAY 2,(@101)    ! Set a 2 second time delay for
                                  channel 101.
```

Performing a Scan

Once you set up a scan list and configure the scan, the actual scan can be performed.

- If a scan list contains a non-existing channel, the scan cannot be performed and an error will occur.
- If a scan list contains a channel on a digital I/O module that does not work in Mode #1 or Mode #2, the scan cannot be performed and an error will occur (see page 98 for more information about modes).
- If a stored channel setup in the scan list does not match the current hardware configuration, the scan cannot be performed and an error will occur.
- *Front-Panel Operation:* Press **Scan** to begin the scan operation. If you have set the arm source and trigger source to IMMediate, the scan will begin when the key is pressed. If you have configured other arm or trigger sources, the scan will begin when the source criteria are met.

  Stop a scan in progress by pressing **Shift**+**Scan**. The last channel closed in the scan list will remain closed. You cannot pause and then continue a scan. You must start the scan operation over.

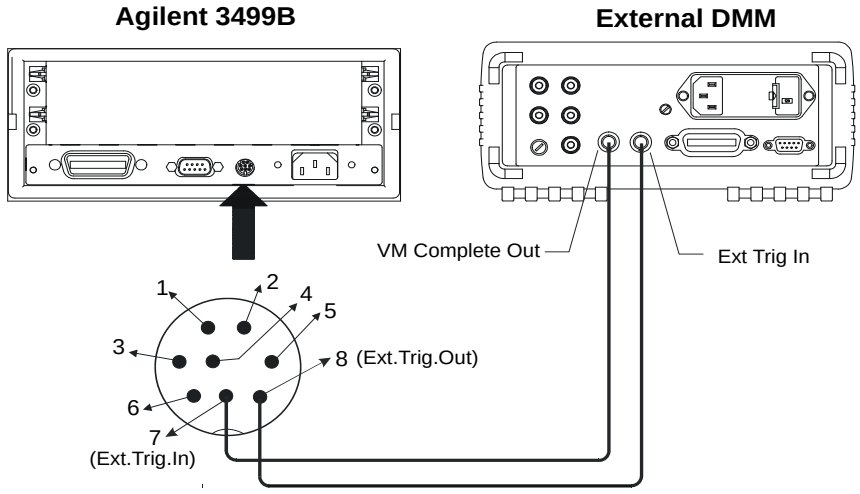
  Press **Step** to start and step through the channels in the scan list, one channel at a time.
- *Remote Interface Operation:* Use the commands shown below to begin a scan or stop a scan in progress. If you abort a scan in progress, the last channel closed in the scan list will remain closed. You cannot pause and then continue a scan. You must start the scan operation over.

  The `INITiate` command moves the instrument from the idle state to the arm layer. The arm source and trigger source will control the actual beginning of the scan.

```
INITiate                    !Initiate the scan.
ABORt                       !Stop the scan.
```

Using External Triggering

Two control lines are provided in the rear panel mini-DIN connector: external trigger in and external trigger out. These lines can be used individually or combined to synchronize a scan list with an external instrument (such as a DMM). The figure below shows this connection. The 3499A/B/C can be configured to output a trigger pulse to notify the external instrument whenever a channel is closed. The arm or trigger source is then configured as either `EXT` or `MIX` so that the 3499A/B/C can receive the notification from the external instrument to advance to the next channel in the scan list.



- In addition to the Ext.Trig.In and Ext.Trig.Out pair provided on the rear panel of the mainframe, the EI (external increment) and CC (channel closed) pair on a 44474A module (see page 248) can also be used to synchronize. Specify either Slot 0 or the slot in which a 44474A module is installed to indicate which lines are to be used.
- Both the built-in trigger lines and the EI/CC lines on the 44474A are TTL compatible.
- Once enabled, the selected trigger-in line is immediately ready to accept the trigger signal from the external instrument. Enabling or disabling a trigger source from the front-panel sets both the trigger in and trigger out functions. On the remote interface, the trigger out function can be controlled independently.

- *Front-Panel Operation:* Press **Menu**, use the knob to select "CONF EXT TRIG" and press **Enter**. Select either slot 0 (built-in external trigger) or the slot where a 44474A is installed and press **Enter**. Enable or disable the pair of trigger lines and press **Enter**. Press the **Menu** key again to exit the menu.

  Press **S.List**, select "CONFIG SCAN", and configure the arm source or trigger source as either `EXT` or `MIX`.

- *Remote Interface Operation:* The following code segment will set up the 3499A/B/C to synchronize with an external instrument.

```
CONFigure:EXTernal:TRIGger:SOURce 0
                                    ! Select to use the built-in
                                      ext.trig.in and ext.trig.out
                                      lines.
CONFigure:EXTernal:TRIGger:OUTPut 1
                                    ! Enable to output a trigger
                                      pulse on the ext.trig.out
                                      line.
ARM:SOURce EXT                      ! Set arm source to EXT.
TRIGger:SOURce EXT                  ! Set trigger source to EXT.
```

Digital I/O Operation

The digital input/output is well-suited for monitoring and controlling external devices. You may use the built-in digital I/O bits or port (on the rear panel), one or more digital I/O modules, or a multifunction modules with a DIO function. In the following context, multifunction modules refer to those with a DIO function.

- The built-in digital I/O (control board) consists of four bits which can be operated either independently as four bit channels (numbered *091* through *094*) or as one 4-bit port (numbered *090*).
- The plug-in digital I/O modules and multifunction modules usually consist of several 8-, 16-, and/or 32-bit ports. These ports can be operated independently, which means one port can be used for output operation, while others can be used for input. However, all bits within a same 8-bit port are dependent. If one bit of a port is used for input or output operation, then all other bits of the same port can only be used for the same operation.

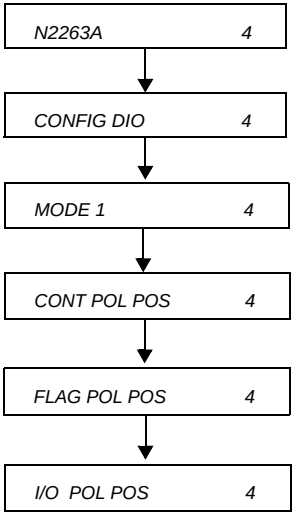
Note For more information about a specific digital I/O module, refer to "Plug-in Modules" starting on page 173.

Digital I/O Configuration

- Parameters such as flow control mode, control line polarity (PCTL), flag line polarity (PFLG), and I/O direction line polarity, are all configured for the plug-in digital I/O modules and multifunction modules. However, these DO NOT apply to the built-in 4-bit digital I/O (on the rear panel).
- The data line polarity of any 8-bit port (or the 4-bit built-in port) can be configured from the front-panel. However, using the remote interface, the data line polarity of any ports (8-, 16-, or 32-bit) can be configured.
- Data display format of any 8-bit port, binary or decimal (default), can only be specified from the front-panel. Once specified, the format applies to all input and output operations on the same port.
- When the instrument is turned on or reset, the handshake mode is set to Mode #1 and the polarities of all configured lines are positive. More information about handshake modes is given starting on page 98.

- *Front-Panel Operation:* Select a digital I/O module and press **Mode**. "CONFIG DIO" is shown in the display. Press **Enter** to show the second-level menu and begin the configuration.

Note Be sure to select the module, not a port or bit. The options on this menu are only available when the module is selected.



Select a DIO module.

Press **Mode**.

Select flow control mode. Press **Enter**.

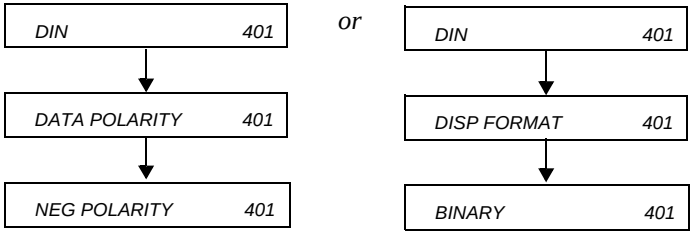
Select the control line polarity. Press **Enter**.

Select the flag line polarity. Press **Enter**.

Select the I/O direction line polarity. Press **Enter**.

Press **Mode** again to exit the menu.

Configure a port. Select a digital I/O port, then press **Mode,** the **CONFIG** annunciator lights up. When "DATA POLARITY" appears in the display, press **Enter** to set data line polarity and/or use the knob to select "DISP FORMAT" and press **Enter** to set data display format for the port.



- *Remote Interface Operation:* Set the flow control parameters using the following SCPI commands. These examples assume a digital I/O module is installed in slot 4.

```
SOURce:DIGital:MODE 4,1          ! Set the flow control mode to
                                   Mode 1.
SOURce:DIGital:CONTrol:POLarity 4,1
                                 ! Set the PCTL line polarity to
                                   negative.
SOURce:DIGital:FLAG:POLarity 4,0
                                 ! Set the PFLG line polarity to
                                   positive.
SOURce:DIGital:IO:POLarity 4,1
                                 ! Set the I/O Direction line
                                   polarity to negative.
```

  Set the data line polarity using the following command.

```
SOURce:DIGital:DATA:BYTE:POLarity 400, POS
                                 ! Set the data line polarity of
                                   8-bit Port 400 to positive.
```

About Flow Control Modes (Handshake)

Five flow control modes are available for Digital I/O operations. Some modes use one or more of the three flow control lines: I/O Direction, PFLG, and PCTL. Select the flow control you need for your digital input/output applications.

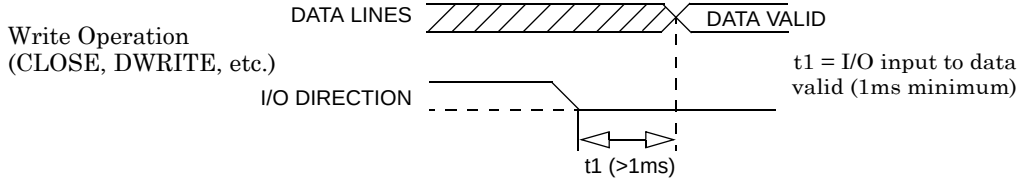
Note

The polarity of the flow control lines is assumed to be positive (the default) in the following diagrams and discussions.

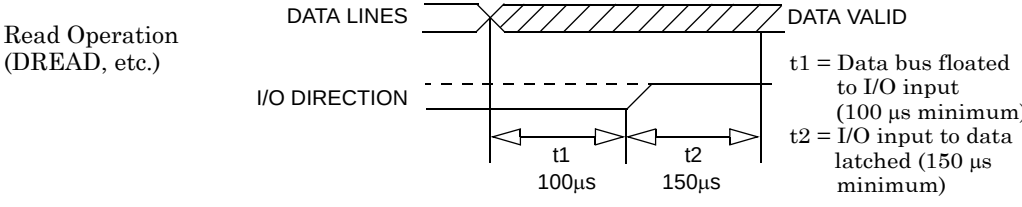
Mode Number	Handshake Mode Definition	Notes
1	Static mode #1	Default handshake mode.
2	Static mode #2	Read what was written.
3	Read or Write and strobe	If you set a port to this mode, you cannot use the port in a scan list or use card pairing (`ROUTe:CPAir`).
4	Read and write strobe	If you set a port to this mode, you cannot use the port in a scan list or use card pairing (`ROUTe:CPAir`).
5	Full handshake	If you set a port to this mode, you cannot use the port in a scan list or use card pairing (`ROUTe:CPAir`).

Static Mode #1

Static Mode #1 is the default mode. In this mode, data is transferred statically, there is no read or write strobe pulses or handshaking. The I/O Direction line is active and indicates direction of transfer. This is shown in the following timing diagrams.



Approximately 1 ms after the I/O direction line goes to a low state, the digital I/O module takes control of the data lines.



100 µs after the 3499A/B/C is instructed to read the data lines, it releases control of the lines and the I/O direction line goes to a high state. 150 µs later the data is actually read (latched).

Static Mode #2

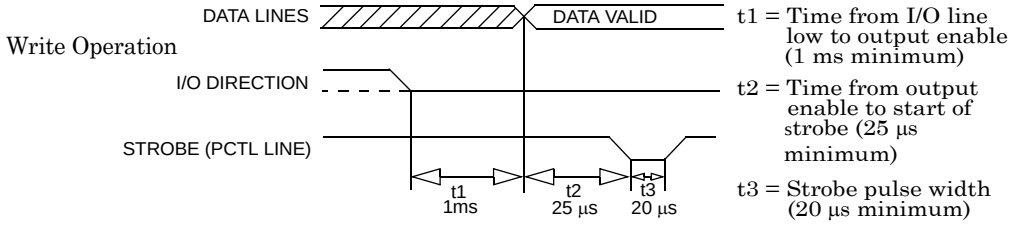
Static Mode #2 acts just like Mode #1 except the output lines are not disabled during an input operation. This means that if a port is written to and then read from, the data read will be that which was just written to it. It is possible, however, that external devices might load the lines and cause a false read.

Timing for the I/O direction line is as shown in Mode #1 for write operations. For read operations, the I/O direction line does not change.

Read or Write and Strobe Mode #3

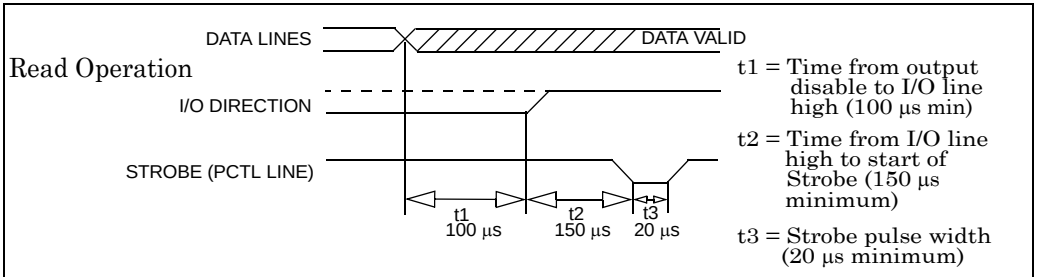
In this mode, the I/O direction line is still used to indicate direction of transfer (input or output) but the PCTL (Peripheral control) line is used to strobe the data.

During a write operation, where the 3499A/B/C writes the data to some external device, the strobe pulse signifies that the data on the 16 or 32 data I/O lines is valid. This is shown in the following timing diagram.



A Strobe pulse signifies that the data on the data lines is valid. During a write operation, the device receiving the data is triggered by the strobe.

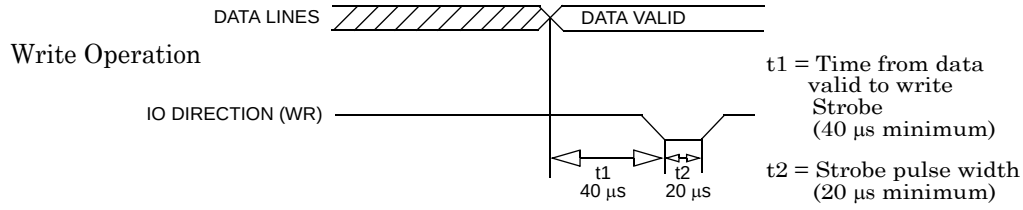
The Strobe pulse is used during a read operation to signify that the 3499A/B/C has completed the read operation. This is shown in the following diagram.



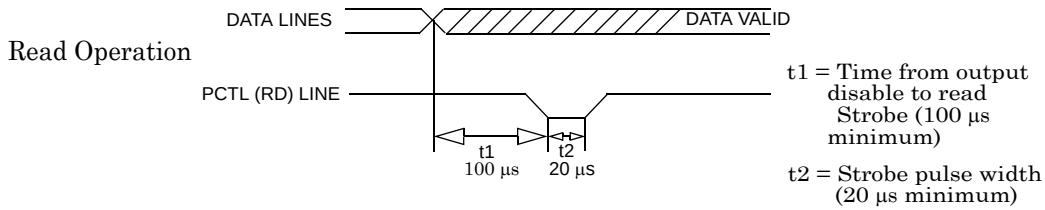
When used during a Read operation, the Strobe pulse signifies that the 3499A/B/C has latched (read) the data from the data lines.

Read and Write Strobe Mode #4

Read and Write Strobe Mode #4 uses the I/O direction line as a Strobe pulse to indicate writing operations. The PCTL line is used to indicate Read operations. It is thus similar to the R/W and Strobe Mode #3 except separate control lines are used for the Strobe pulses and there is no I/O direction line.



The IO Direction line is used to indicate that the data is valid on the data bus lines. IO Direction is used to trigger the receiving device.

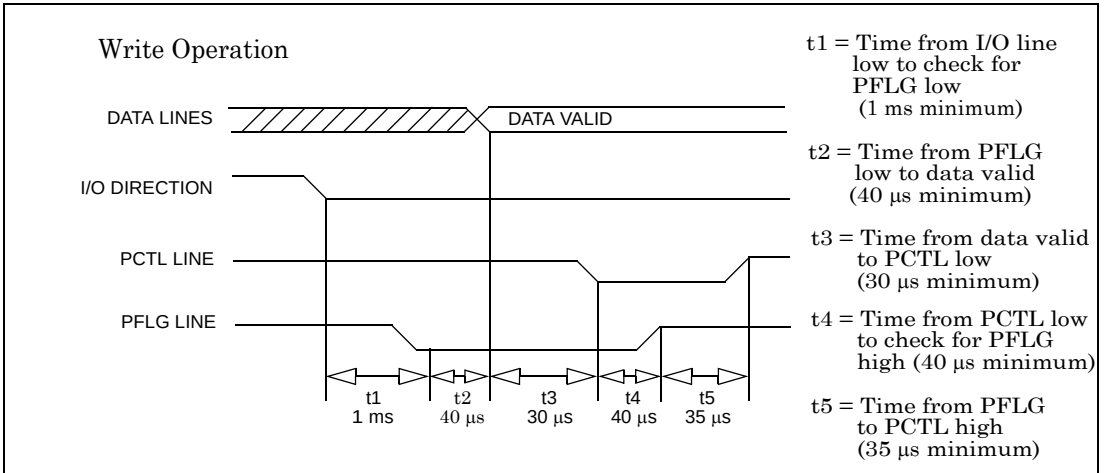


As in Mode #3, the PCTL (RD) line is used to indicate to the sending device that the 3499A/B/C has latched (read) the data.

Full Handshake Mode #5

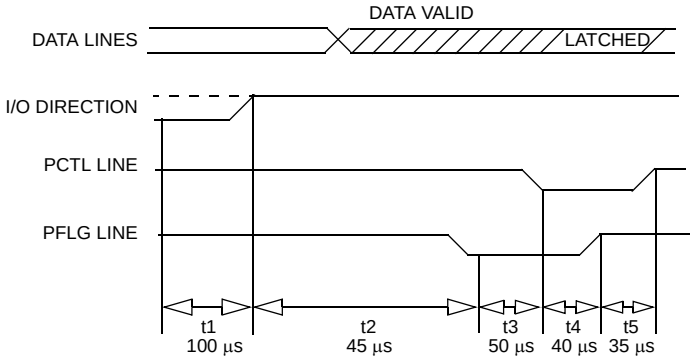
Handshake Mode #5 provides a complete two wire handshake with a data direction line. During write operations, the PCTL line indicates that output data is valid; during read operations, it indicates that the digital I/O module (i.e. N2263A) is "ready for data". The PFLG line is used by the peripheral device to indicate "ready for data" during write operations or "data valid" for read operations.

For this discussion, write operations mean the plug-in digital I/O module is controlling the data lines. Read operations mean external devices control the data lines and the digital I/O module reads the data and controls the PCTL/RD line.


Write Operation
DATA LINES
DATA VALID
I/O DIRECTION
PCTL LINE
PFLG LINE
t1
1 ms
t2
40 µs
t3
30 µs
t4
40 µs
t5
35 µs
t1 = Time from I/O line low to check for PFLG low (1 ms minimum)
t2 = Time from PFLG low to data valid (40 µs minimum)
t3 = Time from data valid to PCTL low (30 µs minimum)
t4 = Time from PCTL low to check for PFLG high (40 µs minimum)
t5 = Time from PFLG to PCTL high (35 µs minimum)

The complete handshaking sequence for Mode #5 is as follows: The 3499A/B/C checks to see if the receiving device has set the PFLG line low, this indicates the receiving device is ready to accept data. When PFLG is low, the 3499A/B/C sets the data on the data bus and sets PCTL low. The 3499A/B/C then waits for the receiving device to set PFLG high, indicating that it has latched the data. To complete the handshake, the 3499A/B/C sets PCTL high.

Read Operation



t1 = Time from output disable to I/O line high (100 µs minimum)

t2 = Time from I/O line high to check for PFLG low (45 µs minimum)

t3 = Time from PFLG low to check for PCTL low (50 µs minimum)

t4 = Time from PCTL low to check PFLG high (40 µs minimum)

t5 = Time from PFLG high to PCTL high and data latched (35 µs minimum)

As with the Write operation, the 3499A/B/C begins by testing PFLG for a low state, indicating that the data is valid. When PFLG is low, the 3499A/B/C sets PCTL low and waits for PFLG to go high. The 3499A/B/C will set PCTL high to indicate that it has completed the data read operation. Data on the data bus must remain valid until after the 3499A/B/C sets PCTL high.

Digital Input Operation

- From the front-panel, you can read data from the built-in digital I/O bits/port (numbered *090* through *094*) or any one of the 8-bit ports on a digital I/O module or multifunction module.
- From the remote interface, you can read data from the individual bit channels and 8-, 16-, or 32-bit ports on a digital I/O module or multifunction module, as well as from the built-in digital I/O bits/port (numbered *090* through *094*).
- Instrument reset will set all digital I/O ports in the instrument as input ports. Pressing **Card Reset** or issuing a `SYST:CPON command` will set all ports on the specified module as input ports (ports on other modules are not affected).
- *Front-Panel Operation:* Select an 8-bit digital I/O port, press **Read** to read the data from the port. The data can be displayed as either decimal or binary (see page 34).
- *Remote Interface Operation:* Use the following command to read an individual bit (bit 6) on a module in slot 4. A "0" (bit cleared) or a "1" (bit set) will be returned.

```
SENSe:DIGital:DATA:BIT? 406     ! Read the bit channel 406.
```

The following commands read values on 8-, 16-, and 32-bit ports:

```
SENSe:DIGital:DATA:BYTE:VALue? 400
                                ! Read the 8-bit Port 400.
SENSe:DIGital:DATA:WORD:VALue? 400
                                ! Read the 16-bit Port 400.
SENSe:DIGital:DATA:LWORD:VALue? 400
                                ! Read the 32-bit Port 400.
```

The range of possible returned values is shown:

Parameter	Decimal Range	Hex range
BYTE	0 to 255	00_h to FF_h
WORD	-32768 to 32767	-8000_h to $7FFF_h$
LWORD	-2^{31} to $(2^{31}-1)$	-80000000_h to $7FFFFFFF_h$

WORD values greater then 32767 and LWORD values greater then for $(2^{31}-1)$ are returned as negative numbers. These values are in 2's complement form.

Digital Output Operation

- From the front-panel, you can write data to the built-in digital I/O bits/port (numbered *090* through *094*) or any one of the 8-bit ports on a digital I/O module or multifunction module.
- From the remote interface, you can write data to individual bit channels and 8-, 16-, or 32-bit ports on a digital I/O module or multifunction module, as well as to the built-in digital I/O bits/port (numbered *090* through *094*).
- Instrument reset will set all digital I/O ports in the instrument as input ports. Pressing **Card Reset** or issuing a `SYST:CPON` command will set all ports on the specified module as input ports (ports on other modules are not affected).
- *Front-Panel Operation:* Select an 8-bit port, press **Write**, the data from the last operation (read or write) will be displayed. Edit the data to the desired value and press **Enter** to write the data to the port. To cancel the write operation, press **Write** again instead of **Enter**. You can edit the data in either binary or decimal form (see page 34).
- *Remote Interface Operation:* The following commands write an individual bit.

```
SOURce:DIGital:DATA:BIT 409,1  ! Write 1 to bit channel 409.
SOURce:DIGital:DATA:BIT 409,0  ! Write 0 to bit channel 409.
```

The following commands write date to 8-, 16-, and 32-bit ports.

```
SOURCE:DIGital:DATA:BYTE 400,128
                                ! Write decimal 128 to 8-bit
                                  port 400.
SOURCE:DIGital:DATA:WORD 400,21845
                                ! Write decimal 21845 to 16-
                                  bit port 400.
SOURCE:DIGital:DATA:LWORD 400, -2114
                                ! Write decimal 4294965182
                                  to 32-bit port 400.
```

WORD values greater then 32767 and LWORD values greater then for (2^{31} -1) are sent as negative numbers. These values are in 2's complement form.

State Storage

The 3499A/B/C provides the capability to store setups, and then recall them to put the instrument back into a known configuration. Information that can be stored includes:

- Status of all relay channels (open or closed)
- Status of digital I/O ports (input or output, flow control, etc.)
- Special module configurations (2-wire, card pair, etc.)
- Scan lists and configuration (arm source, trigger source, etc.)
- Remote interface settings (address, baud, etc.)

Additionally, you can include a stored state in a scan list as a channel.

Firmware Revision Differences

State storage behavior differs depending upon the firmware revision of your 3499A/B/C (see page 59).

- Firmware revision 1.0 must be upgraded. Please contact your nearest Agilent Technologies Office for details.
- Firmware revisions 2.0 and 3.0 allow up to 10 states to be stored. Firmware revision 4.0 allows up to 50 stored states.
- Stored states are lost if power is removed for firmware revisions 2.0 and 3.0. Stored states are preserved when power is removed for firmware revision 4.0.
- Firmware revision 4.0 allows you store a state and apply that state when power is applied to the instrument.
- Storage memory locations are numbered 01 to 10 for Firmware revision 2.0 and 3.0. Memory locations are number 01 to 50 for Firmware revision 4.0.
- Before recalling a stored setup, the instrument verifies that all module types and slot assignment match the setup. If a mismatch is detected, an error (“RECALL FAILED”) will occur.

Firmware Revision Differences (continued)

- An instrument reset does not affect the stored instrument setup information.
- All stored setups will be cleared if the system mode is changed (for example, to 3488A mode).
- Firmware revision 3.0 allows instrument operation in *either* SCPI *or* 3488 mode, *not* both. The mode is selected when the firmware is loaded.

To Store an Instrument State

Firmware revision 2.0 and 3.0 allow up to 10 stored states. Firmware revision 4.0 allows up to 50 stored states. Set the instrument to the state you want to store.

- *Front-Panel Operation:* To store an instrument setup, press **Shift** + **Recall**, select a memory location, and press **Enter**. To cancel the store operation, press **Recall** again instead of **Enter**.
- *Remote Interface Operation:*

```
*SAV 1                    ! Store an instrument setup in
                            memory location 1.
```

Note

Approximately 1 second is required to store an instrument setup into an Agilent 3499A/B/C with Firmware REV 4.0. To avoid errors in when programming, be sure to allow a 1 second interval between the store and recall operations.

To Recall an Instrument State

You can recall a previously stored instrument setup.

- *Front-Panel Operation:* To recall a stored setup, press **Recall**, select the memory location to be recalled, and press **Enter**. To cancel the recall operation, press **Recall** again instead of **Enter**.
- *Remote Interface Operation:*

```
*RCL 1                    ! Recall a previously stored
                            setup from memory
                            location 1.
```

Error Conditions

When an error occurs, the 3499A/B/C will beep and the **ERROR** annunciator on the front-panel lights up. This indicates one or more command syntax or hardware errors have been detected.

- Up to 10 errors can be stored in the instrument error queue. Errors are retrieved in a first-in-first-out (FIFO) manner, which means the first error returned is the first error that was stored.
- If more than 10 errors have occurred, the last error stored in the queue (the most recent error) is replaced with "-350 QUEUE OVERFLOW". No additional errors are stored until you remove errors from the queue. If no errors have occurred when you read the error queue, the instrument responds with "NO ERROR".
- The error queue will be cleared automatically once you read the queue, change the system mode, send the `*CLS` command, or cycle power on the instrument. However, a module reset or an instrument reset will not clear the error queue.
- *Front-Panel Operation:* Press **View,** select "ERROR", and press **Enter**. The first error recorded is displayed. Use the arrow key to scroll through the entire error message, then turn the knob to view other errors in the error queue.
- *Remote Interface Operation:* The errors can be returned as integers or as variant values. When an integer value is returned, you need to associate the integer value with the error (refer to "Error Messages" on page 165). If you return a variant value, the error number and error string are returned. To detect when errors occur using the remote interface, use the SCPI status system (see page 148 for more information).

```
SYSTem:ERRor?                    ! Query the error queue for the
                                   first error.
```

Self-Test

The 3499A/B/C can perform a self-test to verify that it is in proper operation.

- If the self-test is successful, "PASSED" will be displayed on the front-panel. Otherwise, the reason of the failure will be displayed. For details of all self-test failures, refer to "Self-Test Errors" on page 172.
- *Front-Panel Operation:* Press **Menu**, use the knob to select "SELFTEST", and press Enter to perform a self-test.
- *Remote Interface Operation:*

```
*TST?                    ! Returns zero if the test is
                           successful, or non-zero if it
                           fails.
```

Display Control

You can turn off the 3499A/B/C display (for security or increased processing speed for example). You can also write a message of up to 13 characters to the front-panel display.

Note The display cannot be turned off from the front-panel.

- When the display is turned off, the entire front-panel display goes blank except for the **ADRS** and **RMT** annunciators (the **ERROR** annunciator will also be on if there are errors), and all keys except **Local** are locked.
- If the display is turned off, pressing **Local** causes the instrument to return to local operation, the display will be turned back on.
- The display is automatically turned on when power is cycled, or after a `*RST` command.
- When the display is on, you can send a message (up to 13 characters) to display on the front-panel from the remote interface. If you attempt to send more than 13 characters, only the first 13 characters can be displayed. The characters can be letters (A-Z), numbers (0-9), and some special characters (" ' space ( ) * + - , . : ; / \).
- *Remote Interface Operation:*

```
DIAGnostic:DISPlay:STATe OFF    ! Turn off the display.

DIAGnostic:DISPlay:STATe ON     ! Turn on the display.

DIAGnostic:DISPlay "Scan finished"
                                ! Display the message on the
                                  front-panel.
```

Relay Cycle Counts

The Agilent 3499A/B/C can read and track the relay cycle counts on some plug-in modules. This feature can be very useful in switching systems to track relay failures and predict system maintenance requirements.

- This feature is supported by the Agilent N2260A, N2261A, N2262A, N2264A, N2265A, N2266A, N2267A, N2268A, N2270A, N2272A, N2276A, and N2280A/81A/82A modules.
- The cycle counts of the tree relays (*s98 & s99*) on an N2260A or N2266A can also be queried.
- *Front-Panel Operation:* Press **View**, use the knob to select "RELAY CYCLES", and press **Enter**. Turn the knob to select the relay channel of interest. The display shows the channel cycle count.
- *Remote Interface Operation:* Integer values are returned to indicate the cycle count. If you request more than one value, the integers are returned as comma separated values in the same order as the channel in the query command.

```
DIAGnostic:RELay:CYCLes? (@101)
                                    ! Query relay cycle count of
                                      channel 101.
DIAGnostic:RELay:CYCLes? (@101:112)
                                    ! Query the relay cycle count
                                      of the range of channels
                                      from 101 to 112.
```

  You can also query for the maximum relay count on a module. The returned value is the highest count on a module, but you cannot determine which relay the count applies to with this command.

```
DIAGnostic:RELay:CYCLes:MAX? 1 ! Query the maximum relay
                                 cycle count of the module in
                                 slot 1.
```

To Select the System Mode

The instrument can be operated in either SCPI mode or 3488A mode (except Firmware REV 3.0, see page 59 for more details). When shipped from the factory, the instrument is set to the SCPI mode. Perform the following procedure to select the desired system mode for the instrument before any operation.

1. Press **Menu**, the **CONFIG** annunciator lights up. Turn the knob until "SYSTEM MODE" is displayed, then press **Enter**.

   SYSTEM MODE

2. Turn the knob until the desired system mode (i.e. 3488A MODE) is displayed, then press **Enter**.

   HP 3488A MODE

3. The instrument will be reset if the system mode has been changed. Otherwise, it retains the current mode and you can press **Menu** again to exit this operation.

Note Switching between SCPI mode and 3488A mode will reset the instrument to the factory default settings, except the GPIB address which will retain its last setting.

This manual describes programming in the SCPI mode. For information about the 3488 programming mode please visit www.agilent.com.

Remote Interface Reference

Remote Interface Reference

This chapter describes SCPI Commands (Standard Commands for Programmable Instruments) and summarizes IEEE 488.2 Common Commands applicable to the Agilent 3499A/B/C Switch/Control System. The chapter contents include:

- SCPI Command Syntax, on page 115
- 3499A/B/C SCPI Alphabetical Reference, on page 116
- 3499A/B/C SCPI Commands Functionally Grouped, on page 122
- Switch Commands, on page 127
- Specific Plug-in Module Commands, on page 129
- Scanning Commands, on page 132
- Digital I/O Commands, on page 139
- State Storage Commands, on page 147
- Status System Commands, on page 148
- System Information Commands, on page 153
- System-Level Control Commands, on page 156
- RS-232 Commands, on page 160
- About the SCPI Language, on page 161

SCPI Command Syntax

Throughout this manual, the following conventions are used for SCPI command syntax for remote interface programming.

- Square brackets (**[ ]**) indicate optional keywords or parameters.
- Braces (**{ }**) enclose parameter choices within a command string.
- Angle brackets (**< >**) enclose parameters for which you must specify a value.
- A vertical bar (**|**) separates multiple parameters.

Rules for Using a Channel or Scan List

Many of the SCPI commands include a channel list or scan list parameter which allows you to specify one or more channels. The channel number has the form (@*snn*), where *s* is the slot number and *nn* is the channel number. You can specify a slot, a single channel, multiple channels, or a range of channels as described below.

- The following command closes a single channel (channel 11) on the module installed in slot 1:

```
ROUT:CLOS (@111)
```

- The following command closes multiple channels on modules in slots 1 and 2:

```
ROUT:CLOS (@111,112,203,204)
```

- The following command closes a range of channels. When you specify a range of channels, the range may contain invalid channels (they are ignored), but the first and last channel in the list must be valid.

```
ROUT:CLOS (@101:111)
```

- Additional information about channel and slot numbering is given on page 70.

3499A/B/C SCPI Alphabetical Reference

Note Default command parameters are shown in bold.

ABORt

Abort a scan in progress regardless of the trigger source. See page 138.

ARM

`:SOURce <BUS|EXTernal|IMMediate|TIMer|MIX|HOLD>`

Set trigger source in ARM layer. See page 134.

`:SOURce?`

Query trigger source in ARM layer. See page 134.

`:COUNt <number>[MIN|MAX]`

Set counter in ARM layer. See page 134.

`:COUNt? [MIN|MAX]`

Query counter in ARM layer. See page 134.

`:TIMer <seconds>|MIN|MAX`

Set timer for sweep-to-sweep (sweeping). See page 135.

`:TIMer?`

Query timer in arm layer. See page 135.

CONFigure

`:EXTernal[:TRIGger]:SOURce <number>`

Select the trigger source. See page 137.

`:EXTernal[:TRIGger]:SOURce?`

Query the trigger source. See page 137.

`:EXTernal[:TRIGger][:OUTPut] <0|1|OFF|ON>`

Turn off/on the external trigger output. See page 137.

`:EXTernal[:TRIGger][:OUTPut]?`

Query state of external trigger output. See page 137.

DIAGnostic

`:DISPlay[:INFOrmation] <message>`
Display message on front panel. See page 158.

`:DISPlay:STATe <0|1|OFF|ON>`
Disable/Enable display. See page 158.

`:DISPlay:STATe?`
Query state of display. See page 158.

`:MONitor <slot>|<channel>|<port>|-1`
Monitor a slot or a channel/port, or disable a monitor. See page 159.

`:MONitor?`
Query which slot or channel is monitored. See page 159.

`[:RELay]:CYCLes? <channel_list>`
Query relay cycle of the specified channels. See page 155.

`[:RELay]:CYCLes:MAX? <slot>`
Query maximum cycles of channel relays. See page 155.

`[:RELay]:CYCLes:CLEar <channel_list>`
Clear channel relay cycle. See page 155.

`SPEEK? <slot>,<register>`
Read a 8-bit data from the <*register*> specified. See page 131.

`SPOKE <slot>,<register>,<data>`
Write a 8-bit data to the <*register*> specified. See page 131.

INITiate Start a scanning cycle. See page 138.

[ROUTe:]

`[CHANnel:]DELay <seconds>,<channel_list>|ALL`
Set channel-to-channel interval. See page 136.

`[CHANnel:]DELay? <channel_list>`
Query channel-to-channel interval. See page 136.

`CLOSe <channel_list>`
Close one or multiple channels. See page 127.

`CLOSe? <channel_list>`
Queries relay closed state. See page 127.

`CLOSe:STATe?`
Query all closed relays. See page 128.

`CPAir <slot1>,<slot2>|-1`
Pair two cards of the same type or cancel a pair. See page 129.

CPAir?
Query the paired cards. See page 129.

FUNCtion *<slot>,<1|**2**|3|4|WIRE1|**WIRE2**|BIWIRE2|WIRE4>*
Set function mode for N2260A. See page 130.

FUNCtion? *<slot>*
Query the function mode for N2260A. See page 130.

[ROUTe:] (continued)

OPEN *<channel_list>|ALL*
Open one, multiple or all channels. See page 128.

OPEN? *<channel_list>*
Query channels open state. See page 128.

SCAN[:LIST] *<scan_list>*
Set a sequence of channels to be scanned. See page 132.

SCAN[:LIST]?
Query the scan list. See page 132.

SCAN CLEar
Clear the scan list. See page 132.

SCAN:SIZE?
Query the size of the scan list. See page 132.

SOURce:DIGital

:MODE *<slot>,<mode>*
Set the digital I/O mode. See page 140.

:MODE? *<slot>*
Query the digital I/O mode. See page 140.

:CONTrol:POLarity *<slot>,<polarity>*
Set the polarity of control lines. See page 141.

:CONTrol:POLarity? *<slot>*
Query the polarity of control lines. See page 141.

:FLAG:POLarity *<slot>,<polarity>*
Set the polarity of flag lines. See page 141.

:FLAG:POLarity? *<slot>*
Query the polarity of flag lines. See page 141.

SOURce:DIGital (continued)

`:IO:POLarity? <slot>`
Query the polarity of I/O direction lines. See page 141.

`:IO:POLarity <slot>,<polarity>`
Set the polarity of I/O direction lines. See page 141.

`:DATA[:<BYTE|WORD|LWORD>]:POLarity <port>,<0|1|POS|NEG>`
Set the polarity of a port. See page 141.

`:DATA[:<BYTE|WORD|LWORD>]:POLarity? <port>`
Query the polarity of a digital I/O port. See page 141.

`:DATA:BIT <bit_port>,<0|1>`
:Write a 0/1 to a digital I/O bit_port. See page 143.

`:DATA[:<BYTE|WORD|LWORD>[:VALue]] <port>,<data>`
Write a data to the specified port. See page 144.

`:DATA[:<BYTE|WORD|LWORD>]:BLOCK <port>,<block_data>`
Write a block of data to the specified port. See page 144.

`:DATA:[<BYTE|WORD|LWORD>:]TRACE <port>,<sys_mem_name>`
Write the data block in system memory to the specified digital I/O port. See page 145.

`:TRACe:DEFine <sys_mem_name>,<size>[,<fill>]`
Define the size of data block. See page 145.

`:TRACe:DEFine? <sys_mem_name>`
Query the size of data block. See page 145.

`:TRACe:CATalog?`
Query the defined system memory name. See page 145.

`:TRACe[:DATA] <sys_mem_name>,<block_data>`
Write data to the data block in memory. See page 145.

`:TRACe:DELete[:NAME] <sys_mem_name>`
Remove one data block in system memory. See page 145.

`:TRACe:DELete:ALL`
Remove all data block in system memory. See page 145.

SENSe:DIGital

:DATA:BIT? *<bit_port>*
Read the specified bit_port. See page 146.

:DATA[:<**BYTE**|WORD|LWORD>][:VALue]? *<port>*
Read data from the specified port. See page 146.

:DATA[:<**BYTE**|WORD|LWORD>]:BLOCK? *<port>,<size>*
Read a block of data from the specified port. See page 146.

:DATA:[<**BYTE**|WORD|LWORD>:]TRACE <port>,<sys_mem_name>
Read a block of data from the specified port to the predefined memory block. See page 146.

:TRACe[:DATA]? *<sys_mem_name>*
Get the data block being read. See page 146.

STATus

:OPERation:CONDition?
Query the Operation Condition register. See page 150.

:OPERation:ENABle *<unmask>*
Set the Operation Enable register. See page 150.

:OPERation:ENABle?
Query the Operation Enable register. See page 150.

:OPERation[:EVENt]?
Query the Operation Event register. See page 150.

:PRESet
Clear the Standard Operation enable register. See page 150.

SYSMODE *<0|1|**SCPI**|HP3488A>*
Specify a system mode for the instrument. See page 159.

SYSMODE? Query the system mode for the instrument. See page 159.

SYSTem

:CPON *<slot|ALL>*
Reset the module to its power-on state. See page 157.

:CTYPe? *<slot>*
Query the card type and the serial number. See page 153.

:ERRor?
Query the error queue. See page 153.

:LOCal
Set the instrument to local mode. See page 160.

:REMote
Set the instrument to remote mode. See page 160.

:RWLock
Lock all keys on the front panel. See page 160.

:STATe:DELete *<1-10>|ALL*
Clear one or all the previously stored instrument states. See page 147.

:VERSion?
Query the firmware version of the instrument. See page 153.

TRIGger

[:IMMediate]
Software trigger for HOLD off triggering. See page 138.

:SOURce *<BUS|EXTernal|**IMMediate**|TIMer|MIX|HOLD>*
Select trigger source in trigger layer. See page 135.

:SOURce?
Query trigger source in trigger layer. See page 135.

:TIMer *<seconds>|**MINimum**|MAXimum*
Set timer for channel-to-channel (scanning). See page 136.

:TIMer? *<MINimum|MAXimum>*
Query timer in trigger layer. See page 136.

3499A/B/C SCPI Commands Functionally Grouped

Note Default command parameters are shown in bold.

Switch Commands

(*see page 127 for more information*)

```
[ROUTe:]
   CLOSe <channel_list>
   CLOSe? <channel_list>
   CLOSe:STATe?
   OPEN <channel_list>|ALL
   OPEN? <channel_list>
```

Specific Plug-in Commands

(*see page 129 for more information*)

```
[ROUTe:]
   CPAir <slot1>,<slot2>|-1
   CPAir?
   FUNCtion <slot>,<1|2|3|4|WIRE1|WIRE2|BIWIRE2|WIRE4>
   FUNCtion? <slot>

DIAGnostic
   :SPEEK? <slot>,<register>
   :SPOKE <slot>,<register>,<data>
```

Scan List Commands

(*see page 132 for more information*)

```
[ROUTe:]
   SCAN[:LIST] <scan_list>
   SCAN[:LIST]?
   SCAN CLEar
   SCAN:SIZE?
```

Scan Configuration Commands

(*see page 134 for more information*)

```
ARM
    :SOURce <BUS|EXTernal|IMMediate|TIMer|MIX|HOLD>
    :SOURce?
    :COUNt <number>|MIN|MAX|INFinity
    :COUNt? [MIN|MAX|INFinity]
    :TIMer <seconds>|MIN|MAX
    :TIMer? [MINimum|MAXimum]

TRIGger
    :SOURce <BUS|EXTernal|IMMediate|TIMer|MIX|HOLD>
    :SOURce?
    :TIMer <seconds>|MIN|MAX
    :TIMer? [MIN|MAX]

[ROUTe:]
    [CHANnel:]DELay <seconds>,<channel_list>|ALL
    [CHANnel:]DELay? <channel_list>

CONFigure
    :EXTernal[:TRIGger]:SOURce <slot>
    :EXTernal[:TRIGger]:SOURce?
    :EXTernal[:TRIGger][:OUTPut] <0|1|OFF|ON>
    :EXTernal[:TRIGger][:OUTPut]?
```

Scanning Commands

(*see page 138 for more information*)

```
INITiate

ABORt

TRIGger
    [:IMMediate]

*TRG
```

Digital Input Commands

(*see page 142 for more information*)

```
SENSe:DIGital:DATA
    :BIT? <bit_port>
    [:<BYTE|WORD|LWORD>][:VALue]? <port>
    [:<BYTE|WORD|LWORD>]:BLOCK? <port>,<size>
```

Digital Output Commands

(*see page 143 for more information*)

```
SOURce:DIGital:DATA
    :BIT <bit_port>,<0|1>
    [:<BYTE|WORD|LWORD>][:VALue] <port>,<data>
    [:<BYTE|WORD|LWORD>]:BLOCK <port>,<block_data>
```

Digital Configuration Commands

(*see page 140 for more information*)

```
SOURce:DIGital
    :MODE <slot>,<mode>
    :MODE? <slot>
    :CONTrol:POLarity <slot>,<0|1|POS|NEG>
    :CONTrol:POLarity? <slot>
    :FLAG:POLarity <slot>,<0|1|POS|NEG>
    :FLAG:POLarity? <slot>
    :IO:POLarity <slot>,<0|1|POS|NEG>
    :IO:POLarity? <slot>

SOURce:DIGital:DATA
    [:<BYTE|WORD|LWORD>]:POLarity <port>,<0|1|POS|NEG>
    [:<BYTE|WORD|LWORD>]:POLarity? <port>
```


Digital I/O Memory Commands

(*see page 145 for more information*)

```
SOURce:DIGital:DATA
    [:<BYTE|WORD|LWORD>]:TRACe <port>,<sys_mem_name>

SOURce:DIGital:TRACe
    :DEFine <sys_mem_name>,<size>[,<fill>]
    :DEFine? <sys_mem_name>
    :DEFine:CATalog?
    [:DATA] <sys_mem_name>,<block_data>
    :DELete[:NAME] <sys_mem_name>
    :DELete:ALL

SENSe:DIGital:DATA
    [:<BYTE|WORD|LWORD>]:TRACe <port>,<sys_mem_name>

SENSe:DIGital
    :TRACE[:DATA]? <sys_mem_name>
```

State Storage Commands

(*see page 147 for more information*)

```
*SAV <mem>

*RCL <mem>

SYSTem
    :STATe:DELete <mem>|ALL
```

Status System Commands

(*see page 148 for more information*)

```
*CLS

*ESE <value>
*ESE?

*SRE <value>
*SRE?

*STB?

STATus
    :OPERation:CONDition?
    :OPERation:ENABle <unmask>
    :OPERation:ENABle?
    :OPERation[:EVENt]?
    :PRESet
```

System Information Commands

(*see page 153 for more information*)

```
*IDN?

SYSTem
    :CTYPE? <slot>
    :ERRor?
    :VERSion?

DIAGnostic
    [:RELay]:CYCLes? <channel_list>
    [:RELay]:CYCLes:MAX? <slot>
    [:RELay]:CYCLes:CLEar <channel_list>
```

System-Level Control Commands

(*see page 156 for more information*)

```
*OPC
*OPC?

*RST

*TST?

*WAI

SYSTem
    :CPON <slot|ALL>

DIAGnostic
    :DISPlay[:INFOrmation] <message>
    :DISPlay:STATe <0|1|OFF|ON>
    :DISPlay:STATe?
    :MONitor <slot>|<channel>|<port>|-1
    :MONitor?

SYSMODE <0|1|SCPI|HP3488>
SYSMODE?
```

RS-232 Commands

(*see page 160 for more information*)

```
SYSTem
    :LOCal
    :REMote
    :RWLock
```

Switch Commands

These ROUTe commands are intended for use with all switching plug-in modules. You cannot use these commands to change the state of bits in a digital I/O module.

[ROUTe:]
CLOSe <*channel_list*>
CLOSe? <*channel_list*>

This command closes the switching channels specified in the *channel_list*. The *channel_list* has the form @*snn*, where *s* is the slot number and *nn* is the channel number. For all mainframes, slot 0 refers to the 3499A/B/C control board. Valid slot numbers are:

3499A	slots 0 through 5
3499B	slots 0 through 2
3499C	slots 0 through 9

The channel number, *nn*, is plug-in module dependent. Channel numbers for plug-in modules are listed on page 70.

To close:

- a single channel, use CLOS (@snn);
- multiple channels, use CLOS (@snn,snn...);
- sequential channels, use CLOS (@snn:snn);
- groups of sequential channels, use CLOS (@snn:snn,snn:snn);
- or any combination of the above.

Channels in a *channel_list* may not close simultaneously. The order in which the channels close when operated by a single command is not guaranteed. Use sequential CLOSe commands if needed.

The CLOS? query returns a "1" for a closed channel and a "0" for an open channel. If you specify a list of channels, the query returns a comma separated list of 0's and 1's, in the same order as the *channel_list*. The returned values indicate the programmed state of the relay. This query does not physically monitor a relay and cannot report a failed relay.

```
[ROUTe:]
   CLOSe:STATe?
```

This query returns a comma-delineated list of the closed channel relays for all relays on all installed plug-in modules. The returned values will be in the form *snn*, where *s* is the slot number and *nn* is the channel number. The returned values indicate the programmed state of the relay. This query does not physically monitor a relay and cannot report a failed relay.

```
[ROUTe:]
   OPEN <channel_list>|ALL
   OPEN? <channel_list>
```

This command opens all the switching channels specified in the *channel_list*. The *channel_list* has the form *@snn*, where *s* is the slot number and *nn* is the channel number. See the `CLOSe` command description for a description of *channel_list*.

The `OPEN?` query returns a "1" for open channels and a "0" for a closed channel. If you specify a list of channels, the query returns a comma separated list of 0's and 1's, in the same order as the *channel_list*. The returned values indicate the programmed state of the relay. This query does not physically monitor a relay and cannot report a failed relay.

Specific Plug-in Module Commands

[ROUTe:]
CPAir <*slot1*>,<*slot2*>|-1
CPAir?

This command is used to group two cards of the same type together - effectively assigning both cards to both slot numbers. When a command is sent to one of the paired cards, that command is executed on both cards in succession - lowest slot number first. The card pair feature is especially useful when doing 4-wire scanning. Only two identical plug-in modules can be paired. Modules that can be paired include the switching modules (MUX, GP and Matrix), the digital I/O modules, and the multifunction modules.

The slot 0 refers to the 3499A/B/C control board. Valid slot numbers are:

3499A	slots 1 through 5
3499B	slots 1 through 2
3499C	slots 1 through 9

After two switching modules are paired, opening/closing/scanning one or more channels on either one of the paired modules will result in the same operation on the respective channels on the other module being performed at the same time.

The **N2260A** and **N2266A** are configurable MUX modules. Only when both modules are configured to the same function, can the two modules be paired. Once paired, changing the function of one module will be duplicated on the other module in the pair. Page 130 gives additional details about the N2260A and N2266A configuration.

You can pair DIO modules if they are used in handshake Mode #1 or #2 (but not in Mode #3 or #4 or #5). Once paired, writing data on either one of the paired modules will write the data on the other module.

You can cancel a card pair by specifying a "**-1**" for the second <*slot*> parameter. There will be no paired cards after an instrument power-on or reset.

The `ROUTe:CPAir?` query returns a list of four numbers separated with commas, indicating the four slots in which two pairs of modules are plugged. If there is only one pair, "0,0" will be returned for the last two numbers. 0,0,0,0 is returned if no cards are paired.

For example, using a 3499C mainframe, if you send `ROUT:CPA 1,3` to pair the modules in slots 1 and 3, the `ROUT:CPA?` query will return:

```
1,3,0,0
```

```
[ROUTe:]
   FUNCtion <slot>,<1|2|3|4|WIRE1|WIRE2|BIWIRE2|WIRE4>
   FUNCtion? <slot>
```

`[ROUTe:]FUNCtion` is used to configure a **N2260A** (see page 176) or **N2266A** (see page 200) 40-channel MUX module. Four configurations are possible:

- 80-channel 1-wire MUX
- 40-channel 2-wire MUX
- two 20-channel 2-wire MUXs
- 20-channel 4-wire MUX

After an instrument power on or reset, the module will return to the default 40-channel 2-wire MUX mode. Changing function mode will open all the switching channels on a module.

1-Wire Mode (`1|WIRE1`) configures the MUX as an 80-channel single-ended (1-wire) MUX module. The valid channel numbers are *s*00 to *s*79. The Low (L) terminals form channels 00 through 39, the High (H) terminals form channels 40 through 79. Only one channel can be closed at a time when in 1-wire mode.

2-Wire Mode (`2|WIRE2`) configures the MUX as a 40-channel 2-wire MUX module. The valid channel numbers are *s*00-*s*39. To close/open/scan one channel is actually to close/open/scan a 2-wire pair.

Dual 2-Wire Mode (`3|BIWIRE2`) configures the MUX as two independent 20-channel 2-wire MUX modules. The valid channel numbers are *s*00-*s*39 (*s*00-*s*19 for the first MUX and *s*20-*s*39 for the second).

4-Wire Mode (`4|WIRE4`): This mode configures the N2260A or N2266A as a 20-channel 4-wire MUX module. Channels 20 through 39 (2-wire) are automatically paired with Channels 00 through 19. The valid channel numbers are *s*00-*s*19. To close/open/scan a channel is actually closing/opening/scanning a 4-wire connection in this mode.

If two modules are paired, changing the configuration on one module will result in the other module being changed to the same configuration. Two modules CANNOT be paired if they are configured differently.

The [ROUTe:]FUNCtion? query returns the current configuration of the module in the specified slot. The returned string will be one of WIRE1, WIRE2, BIWIRE2, or WIRE4. An error is generated if no module is installed.

```
[ROUTe:]
DIAGnostic
    :SPEEK? <slot>,4
    :SPOKE <slot>,0,<data>
```

These commands read and write an 8-bit data register on the 44475A Breadboard Module (see page 251).

Using these commands with newer modules (models beginning with **N22xxx**) will generate an error.

Valid *slot* numbers are:

3499A	slots 1 through 5
3499B	slots 1 through 2
3499C	slots 1 through 9

DIAG:SPEEK? returns a decimal number representing the binary weighted values of the bits in the register connected to the DI lines of the breadboard. 4 is the register number. Any other register number will not generate an error and will return the value 255.

DIAG:SPOKE writes a decimal number (<*data*>) representing the binary weighted values of the bits to the register connected to the DO lines of the breadboard. 0 is the register number. Any other register number will not generate an error but will have no effect.

In the form of the value returned or written as *data*, a "1" represents a TTL high and a "0" represents a TTL low on the DI or DO line.

Scanning Commands

The Agilent 3499A/B/C can scan switching channels, digital I/O bit channels, and even the stored channel setups in a scan list. You can combine scanned channels with an external measurement device or source and synchronize the scan with the measurements.

To perform scanning you must:

1. create a scan list
2. configure the scan
3. initiate the scan
4. trigger the arm layer
5. trigger the trigger layer

The rules for scanning are described on page 85.

Scan List Commands

```
[ROUTe:]
    SCAN[:LIST] <scan_list>
    SCAN[:LIST]?
    SCAN CLEar
    SCAN:SIZE?
```

The `ROUTe:SCAN:LIST` command creates a scan list. A scan list can contain any combination of switch channels, digital bits, or stored channel states (see page 106).

The *scan_list* has the form *@snn*, where *s* is the slot number and *nn* is a specific channel number. For all mainframes, slot 0 refers to the 3499A/B/C control board. Valid slot numbers are:

3499A	slots 0 through 5
3499B	slots 0 through 2
3499C	slots 0 through 9

The channel numbers, *nn*, are plug-in module dependent. Channel numbers for specific plug-in modules are listed on page 70.

To create a scan list using:

- a single channel, use `SCAN (@snn);`
- multiple channels, use `SCAN (@snn,snn...);`
- sequential channels, use `SCAN (@snn:snn);`
- groups of sequential channels, use `SCAN (@snn:snn,snn:snn);`
- or any combination of the above.

Any digital I/O lines included in *scan_list* must be operating in handshake Mode #1 or #2. The 4-bit built-in digital I/O bits (*091-094*) can be included in a *scan_list*.

N2260A and N2266A: The configuration must be specified before defining the channels or channel range to be scanned. Page 130 describes the configuration. The two tree relays (*s*98 and *s*99) can not be included in a *scan_list*.

A scan list may contain up to 200 entries. One channel setup, regardless of its channel number, is counted as one "channel" in a *scan_list*.

The `ROUTe:SCAN:LIST?` query returns the sequence of channels included in the *scan_list*. A comma-delineated channel list is returned. The list is in same order as in the *scan_list* and in the form of (*snn*,*snn*,*mm*,...), where *snn* is the channel number and *mm* is a stored channel setup.

The `ROUTe:SCAN CLEar` command clears the scan list. This command has no effect on the scan configurations except clearing all the channels/ bits or the stored channel setups included in the <*scan_list*>.

The `ROUTe:SCAN:SIZE?` query returns the number of channels in the *scan_list*. The returned value is an integer number between 0 and 200. A stored setup in the scan is counted as one "channel".

Scan Configuration Commands

These command set the arm and trigger layer parameters. See "The Scan Process" on page 86 for a complete description of the layers and scan configuration process.

ARM
:SOURce <BUS|EXTernal|IMMediate|TIMer|MIX|HOLD>
:SOURce?

This command specifies the event control source for the arm layer. A complete description of the arm layer and how it relates to scanning begins on page 85. The ARM source can be specified to be one of the following:

- BUS - the sweep of the scan list starts after a *TRG or GET is received.
- EXTernal - the sweep of scan list starts after an external trigger is received.
- IMMediate - the sweep of scan starts immediately after INITiate (or the end of a scan if multiple scans are specified).
- TIMer - the sweep of the scan list starts after the timer interval.
- MIX - the scan will continue after a BUS or EXTernal event occurs.
- HOLD - the sweep of the scan list starts when a TRIGger[:IMMediate] command is received.

After the power is applied or a reset (*RST) command is received, the default ARM source is IMMediate.

The ARM:SOURce? query returns a string. Possible values retuned include: BUS, EXTernal, IMMediate, TIMer, MIX, or HOLD.

ARM
:COUNt <*number*>|MIN|MAX|INFinity
:COUNt? [MIN|MAX|INFinity]

This command sets the number of times the scan list is performed. MIN specifies a single sweep, MAX specifies 99,999 sweeps, and INF continues sweeping the scan list indefinitely (until an ABORt command is received). Following power on or a reset (*RST) command, the ARM:COUNt is set to 1 (MIN).

The ARM:COUNt? query returns the number of scanning cycles set by ARM:COUNt. The optional parameters MIN and MAX allow you to query the module for these values instead of looking them up in the command reference. MIN returns "1", MAX returns "99999", and INF returns "-1".

ARM
:TIMer <*seconds*>|MIN|MAX
:TIMer? [MIN|MAX]

This command sets the sweep-to-sweep interval in the arm layer (the TRIGger:TIMer command sets the channel-to-channel interval in the trigger layer). This timer is valid only if the TIMer is set using the ARM:SOURce command.

You can set *seconds* to any value between 0.000 (MIN) and 99999.999 (MAX) in increments of 0.001 seconds. When power is applied the value is set to 0 (MIN).

The ARM:TIMer? query returns the sweep-to-sweep interval in seconds. The returned number is a value between 0 and 99999.999 (seconds). The optional parameters MIN and MAX allow you to query the module for these values instead of looking them up in the command reference. MIN returns "0" and MAX returns "99999".

TRIGger
:SOURce <BUS|EXTernal|IMMediate|TIMer|MIX|HOLD>
:SOURce?

This command specifies the event control source for the trigger layer. A complete description of the trigger layer and how it relates to scanning begins on page 85. The TRIGger source can be specified to be one of the following:

- BUS - the scan advances after a *TRG or GET is received.
- EXTernal - the scan list advances after an external trigger is received.
- IMMediate - the scan advances immediately after the previous channel is closed (if no ROUTe:CHANnel:DELay value is set).
- TIMer - the scan advances after the timer interval.
- MIX - the scan advances after a BUS or EXTernal event occurs.
- HOLD - the sweep of the scan list starts when a TRIGger[:IMMediate] command is received.

After the power is applied or a reset (*RST) command is received, the default TRIGger source is IMMediate.

The TRIGger:SOURce? query returns a string. Possible values retuned include: BUS, EXTernal, IMMediate, TIMer, MIX, or HOLD.

TRIGger
:TIMer <*seconds*>|MIN|MAX
:TIMer? [MIN|MAX]

This command sets the channel-to-channel interval in the trigger layer (the ARM:TIMer command sets the sweep-to-sweep interval in the trigger layer). This timer is valid only if the TIMer is set using the TRIGger:SOURce command.

You can set *seconds* to any value between 0.000 (MIN) and 99999.999 (MAX) in increments of 0.001 seconds. When power is applied, the value is set to 0 (MIN).

The TRIGger:TIMer? query returns the channel-to-channel interval in seconds. The returned number is a value between 0 and 99999.999 (seconds). The optional parameters MIN and MAX allow you to query the module for these values instead of looking them up in the command reference. MIN returns "0" and MAX returns "99999".

[ROUTe:]
[CHANnel:]DELay <*seconds*>,<*channel_list*>|ALL
[CHANnel:]DELay? <*channel_list*>

This command specifies a delay time (from 0 to 99999.999 seconds, with 1 ms resolution) between when a channel in the scan list is closed and the next operation begins (and, if configured, a *trigger out pulse* is sent). The delay time can be set individually for each channel in the scan list, or one delay can be set for all channels in the scan list. Note that, even if the trigger source is set to IMMediate, the scan list will not advance until the delay time is met. Following power on or a reset (*RST) command, the delay time is set to "0".

The *channel_list* can be:

- a single channel, use DEL (@snn);
- multiple channels, use DEL (@snn,snn...);
- sequential channels, use DEL (@snn:snn);
- groups of sequential channels, use DEL (@snn:snn,snn:snn);
- or any combination of the above.

The ROUTe:CHANnel:DELay? query returns the delay time of each channel included in the *channel_list*. A comma-delineated set of values is returned. The values are in same order as in the *channel_list* and in the form of (*snn*,*snn*,*mm*,...), where *snn* is the channel number and *mm* is a stored channel setup.

```
CONFigure
    :EXTernal[:TRIGger]:SOURce <slot>
    :EXTernal[:TRIGger]:SOURce?
    :EXTernal[:TRIGger][:OUTPut] <0|1|OFF|ON>
    :EXTernal[:TRIGger][:OUTPut]?
```

These commands select and enable external triggers. Two possible source are available: the built-in source available at the rear-panel mini-DIN connector or the EI/CC lines in a 44474A DIO Module. For additional information about external triggering see "Using External Triggering" on page 93.

The *slot* parameter in the command sets the location of the external trigger lines. The built-in trigger lines are on slot "0". If a 44474A is installed, *slot* can be set to the corresponding slot number. After power on or a reset (`*RST`) command, the *slot* is set to "0".

The `CONFigure:EXTernal:TRIGger:SOURce?` query returns a number indicating the external trigger source.

The `CONFigure:EXTernal:TRIGger:OUTPut` command enables or disables the external trigger out pulse. This pulse is output after a channel is closed during a scan operation when enabled. The output pulse timing may be delayed after the channel is closed if the `ROUTe:CHANnel:DELay` command has been set for the channel. After power on or a reset (`*RST`) command is received, the output pulse is disabled (`OFF`).

The `CONFigure:EXTernal:TRIGger:OUTPut?` query returns either a "0" (disabled) or "1" (enabled) indicating the status of the external trigger output.

Scanning Commands

These commands enable the scan, stop the scan, and provide triggers for arm and trigger layer sources.

INITiate

This command takes the instrument out of the idle state and moves it to the arm layer. If the ARM:SOURce is set to IMMediate, the instrument moves directly to the trigger layer. If the TRIGger:SOURce is set to IMMediate, the scan begins.

You must always send the INITiate command to move the instrument out of the idle state, regardless of the arm and trigger sources used. For example, if you set the arm source to EXTernal, the instrument will not move to the trigger layer until the INITiate command is received and then an external trigger occurs.

ABORt

This command stops a scan in progress. This command does not affect the scan configuration or the scan list. A reset (*RST) command will also stop a scan in progress, but the scan configuration and scan list are lost.

When a scan is aborted, the channel last scanned before the interruption will remain closed. A scan cannot resume from where it is interrupted.

TRIGger[:IMMediate]

This command is used as a trigger source in the arm or trigger layer when the SOURce is set to HOLD.

***TRG**

This IEEE-488.2 common command is used as a trigger source in the arm or trigger layer when the SOURce is set to BUS.

Digital I/O Commands

You may use the built-in digital I/O bits or port, one or more digital I/O modules, or a multifunction modules with a DIO function. In the following context, multifunction modules refer to those with a DIO function.

- The built-in digital I/O (control board) consists of four bits which can be operated either independently as four bit channels (numbered *091* through *094*) or as one 4-bit port (numbered *090*).
- The plug-in digital I/O modules and multifunction modules usually consist of several 8-, 16-, and/or 32-bit ports. These ports can be operated independently, which means one port can be used for output operation, while others can be used for input. However, all bits within a same 8-bit port are dependent. If one bit of a port is used for input or output operation, then all other bits of the same port can only be used for the same operation.

For a complete discussion of digital I/O operation refer to “Digital I/O Operation” on page 95.

Digital Configuration Commands

These commands set the digital I/O handshake mode, handshake line polarities, and data line polarities. The *port* parameter is in the form *snn*, where *s* is the slot number and *nn* is the first channel on the digital port. The *port* parameter is plug-in module dependent. Valid port numbers for each plug-in module are shown beginning on page 70.

SOURce:DIGital
:MODE <*port*>,<*mode*>
:MODE? <*port*>

This command sets the handshake mode to use. Five handshake modes are available and are specified as an integer from 1 to 5. See "About Flow Control Modes (Handshake)" on page 98. The modes are shown below.

Mode Number	Handshake Mode Definition	Notes
1	Static mode #1	Default handshake mode.
2	Static mode #2	Read what was written.
3	Read or Write strobe	If you set a port to this mode, you cannot use the port in a scan list or use card pairing (`ROUTe:CPAir`).
4	Read and write strobe	If you set a port to this mode, you cannot use the port in a scan list or use card pairing (`ROUTe:CPAir`).
5	Full handshake	If you set a port to this mode, you cannot use the port in a scan list or use card pairing (`ROUTe:CPAir`).

Only the first port on a digital I/O module can be set to mode #3, mode #4, or mode #5. When set to modes 3, 4, or 5, the three control lines are valid for the port used. Other ports on the same module can be used in modes #1 or #2 (the three control lines do not apply to these ports).

This command cannot be used with the built-in 4-bit digital I/O port.

The `SOURce:DIGital:MODe?` query returns an integer ranging from 1 to 5.

```
SOURce:DIGital
    :CONTrol:POLarity <slot>,<0|1|POS|NEG>
    :CONTrol:POLarity? <slot>
    :FLAG:POLarity <slot>,<0|1|POS|NEG>
    :FLAG:POLarity? <slot>
    :IO:POLarity <slot>,<0|1|POS|NEG>
    :IO:POLarity? <slot>
```

These commands set the polarity of the three handshake lines. The `CONTrol` portion of the command works with the PCTL (Peripheral control) line. The `FLAG` portion of the command works with the PFLG (peripheral flag) line. The `IO` portion of the command works with the I/O direction line.

The *slot* parameter is a decimal ranging from 1 to 5. These commands do not work with the built-in 4-bit digital I/O port (0).

Following power on or a reset (`*RST`) command, the polarities are set to `0` or `POSitive`.

The query versions of these commands return one of two strings: POS or NEG.

```
SOURce:DIGital:DATA
    [:<BYTE|WORD|LWORD>]:POLarity <port>,<0|1|POS|NEG>
    [:<BYTE|WORD|LWORD>]:POLarity? <port>
```

This command sets the data line polarity for the specified port. The current state of the data lines is not changed by this command.

Following power on or a reset (`*RST`) command, the polarity is set to 0 or POS.

Digital Input Commands

These commands read individual bits or complete ports. Some digital I/O configuration commands may affect how these bits are read. The *port* parameter is in the form *snn*, where *s* is the slot number and *nn* is the first channel on the digital port. The *port* parameter is plug-in module dependent. Valid port numbers for each plug-in module are shown beginning on page 70.

SENSe:DIGital:DATA
:BIT? <*bit_port*>

This query reads a bit from the specified *bit_port* and returns either a "0" or a "1". *bit_port* is in the form of *snn*, where *s* is the slot number and *nn* is the bit number. The built-in 4-bit digital I/O port has bit numbers 091 to 094. The plug-in module bit numbers are module dependent (see page 70).

SENSe:DIGital:DATA
[:<BYTE|WORD|LWORD>][:VALue]? <*port*>

This query reads data from the specified port and returns an integer representing the binary-weighted value of the bits. The value returned depends upon the first parameter as follows:

- **BYTE** - reads 8 bits and returns an integer between 0 and 255 (00_h and FF_h).
- **WORD** - reads 16 bits and returns an integer between -32768 and +32767 (-8000_h and $+7FFF_h$). Negative numbers returned are 2's complement numbers.
- **LWORD** - reads 32 bits and returns an integer between -2^{31} and $+(2^{31}-1)$ (-80000000_h and $7FFFFFFF_h$). Negative numbers returned are 2's complement numbers.

Numbers greater than +32767 (WORD) and $+(2^{31}-1)$ (LWORD) will be returned as negative numbers. When the returned data is negative, you must calculate the actual bit state from the 2's complement form.

SENSe:DIGital:DATA
[:<BYTE|WORD|LWORD>]:BLOCK? <*port*>,<*size*>

This query returns block data. Block data has the form: <*#digits*><*length*><*block*>, where:

- <*#digits*> decides how many decimal digits are used to define <*length*>;
- <*length*> decides how many bytes are to be transferred in <*block*>;
- <*block*> contains the actual data to be transferred. <*block*> may contain from 1 to 2048 bytes.

The returned block will contain the number bytes specified in <*size*>. The value of *size* will be the value of *length* in the returned block.

Set *port* to 090 to read blocks on the built-in 4-bit digital I/O port.

The first parameter sets the value returned. If you omit the parameter, BYTE data is assumed.

Digital Output Commands

These commands set individual bits or complete ports. Some digital I/O configuration commands may affect how these bits are implemented. The *port* parameter is in the form *snn*, where *s* is the slot number and *nn* is the first channel on the digital port. The *port* parameter is plug-in module dependent. Valid port numbers for each plug-in module are shown beginning on page 70.

SOURce:DIGital:DATA
:BIT <*bit_port*>,<0|1>

This command sets a bit in the specified *bit_port*. *bit_port* is in the form of *snn*, where *s* is the slot number and *nn* is the bit number. The built-in 4-bit digital I/O port has bit numbers 091 to 094. The plug-in module bit numbers are module dependent (see page 70).

SOURce:DIGital:DATA
[:<BYTE|WORD|LWORD>][:VALue] <*port*>,<*data*>

This command sets a value on the specified port. *data* is a decimal value representing the desired bit pattern. The value of *data* depends upon the first parameter as follows:

- **BYTE** - writes 8 bits to the specified port. 16- or 32-bit modules will be used as two or four 8-bit ports respectively. *data* can range from 0 to 255 (00_h and FF_h). If writing to the built-in 4-bit digital I/O port (*port* = 090), *data* can range from 0 to 15.
- **WORD** - writes 16 bits to the specified port. 16- or 32-bit modules will be used as one or two 16-bit ports respectively. *data* can range from -32768 to +32767 (-8000_h and $+7FFF_h$). Values above 32767 must be converted to the 2's complement form and sent as negative numbers.
- **LWORD** - writes 32 bits to the specified port. This parameter is only valid on 32-bit modules. *data* can range from -2^{31} and $+(2^{31}-1)$ (-80000000_h and $7FFFFFFF_h$). Values above $+(2^{31}-1)$ must be converted to the 2's complement form and sent as negative numbers.

SOURce:DIGital:DATA
[:<BYTE|WORD|LWORD>]:BLOCK <*port*>,<*block_data*>

This writes block data to the specified port. Block data has the form: <#*digits*><*length*><*block*>, where:

- <#*digits*> decides how many decimal digits are used to define <*length*>;
- <*length*> decides how many bytes are to be transferred in <*block*>;
- <*block*> contains the actual data to be transferred. <*block*> may contain from 1 to 2048 bytes.

Set *port* to 090 to write blocks to the built-in 4-bit digital I/O port.

The first parameter sets how the value of *block_data* is interpreted. If you omit the parameter, BYTE data is assumed.

For example, the command below sends a block of data, "ABCDEFGHIJ", to 16-bit port 100. Since the ASCII characters A and B have decimal values of 65 and 66, respectively, the binary equivalent of 65 and 66 are written to port 100. A is written to the upper 8 bits and B to the lower 8 bits; then the C and D are written, and so on.

```
SOUR:DIG:DATA:WORD:BLOCK 100,#210ABCDEFGHIJ
```

Digital I/O Memory Commands

You can use the Agilent 3499A/B/C internal memory to store digital data. After defining the memory, you can put data in memory for later writing to a digital port, or you can read digital port data directly into memory. Two independent blocks of memory can be used. A power on or reset (*RST) command clears all defined memory blocks.

```
SOURce:DIGital:TRACe
    :DEFine <sys_mem_name>,<size>[,<fill>]
    :DEFine? <sys_mem_name>
    :DEFine:CATalog?
```

The SOURce:DIGital:TRACe:DEFine command defines a memory block for use.

The *sys_mem_name* parameter is a string containing up to 12 characters that names the memory block.

size defines the number of bytes to use for the block memory. You can specify memory size from 1 to 32768 bytes. If two memory blocks are being defined (using two SOURce:DIGital:TRACe:DEFine commands) the total memory size defined must not exceed 32768 bytes.

If the *fill* parameter is used, it puts a value into each of the bytes defined in *size*. The value of *fill* can range from 0 to 255 (0 to FF_h).

The SOURce:DIGital:TRACe:DEFine? query returns the size of the memory data block (in bytes). The returned value can range from 1 to 32768.

The SOURce:DIGital:TRACe:CATalog? query returns a string containing the name(s) of defined memory blocks. If two memory blocks are defined, the sting contains both names separated by a comma.

```
SOURce:DIGital:TRACe
    :DELete[:NAME] <sys_mem_name>
    :DELete:ALL
```

These commands remove a memory block previously defined. With the *sys_mem_name* parameter, only one block is removed. The ALL form of the command removes all defined memory blocks.

SOURce:DIGital:TRACe
[:DATA] <*sys_mem_name*>,<*block_data*>

This command loads a memory block with data. The *sys_mem_name* parameter must have been previously defined. The *block_data* is in the form: <#*digits*><*length*><*block*>, where:

- <#*digits*> decides how many decimal digits are used to define <*length*>;
- <*length*> decides how many bytes are to be transferred in <*block*>;
- <*block*> contains the actual data to be transferred. <*block*> may contain from 1 to 2048 bytes.

SOURce:DIGital:DATA
[:<BYTE|WORD|LWORD>]:TRACe <*port*>,<*sys_mem_name*>

This command writes a block of data, stored in a memory location, to the specified port. The memory location must have been defined using the SOURCe:DIGital:TRACe:DEFine command and the data written to the memory location using the SOURCe:DIGital:TRACe command.

SENSe:DIGital:DATA
[:<BYTE|WORD|LWORD>]:TRACe <*port*>,<*sys_mem_name*>

This command reads a block of data from a digital I/O port and puts the data in memory. The *port* parameter is in the form *snn*, where *s* is the slot number and *nn* is the first channel on the digital port. The *port* parameter is plug-in module dependent. Valid port numbers for each plug-in module are shown beginning on page 70.

The BYTE, WORD, or LWORD forms of this command specify 8-, 16-, and 32-bit operations, respectively. If omitted, BYTE is assumed.

SENSe:DIGital
:TRACE[:DATA]? <*sys_mem_name*>

This query returns a block of data from the specified memory location. the data is returned in the form: <#*digits*><*length*><*block*>, where:

- <#*digits*> decides how many decimal digits are used to define <*length*>;
- <*length*> decides how many bytes are to be transferred in <*block*>;
- <*block*> contains the actual data to be transferred. <*block*> may contain from 1 to 2048 bytes.

State Storage Commands

The 3499A/B/C provides the capability to store setups, and then recall them to put the instrument back into a known configuration. The operation of state storage is dependent upon the instrument's firmware revision. Refer to "State Storage" on page 106 for more details.

The *mem* parameter specifies memory locations. Storage memory locations are numbered 01 to 10 for Firmware revisions 1.0, 2.0, and 3.0. Memory locations are number 01 to 50 for Firmware revision 4.0.

Saved states can be used as a channel in scan lists. Saved states are not affected by the reset (`*RST`) command.

`*SAV <mem>`

This IEEE488.2 common command saves the current instrument setup in the memory location specified. A saved memory location can be used in a scan list as a channel.

`*RCL <mem>`

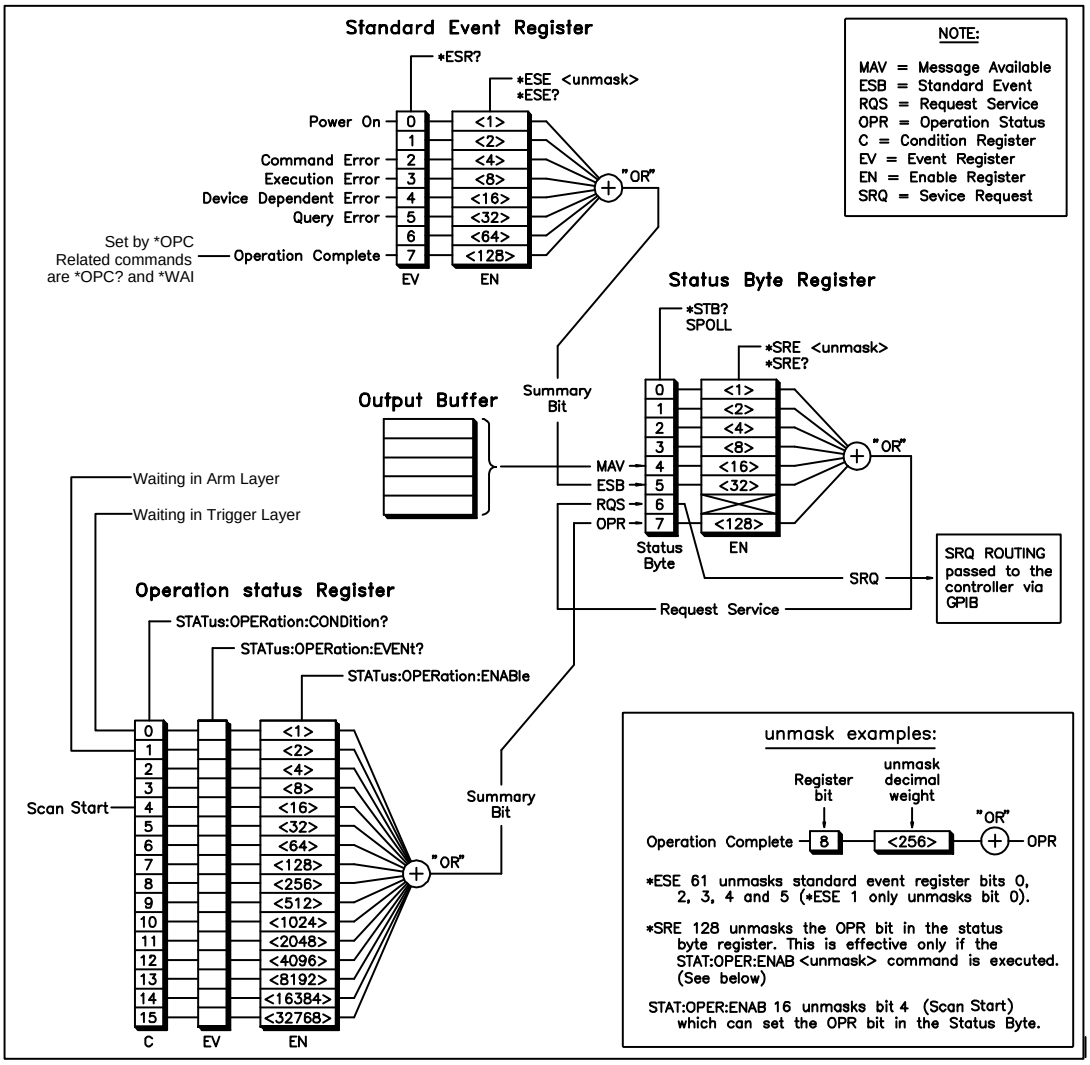
This IEEE488.2 common command restores the instrument to a saved instrument state.

`SYSTem:STATe:DELete <mem>|ALL`

This command deletes a single instrument state or all stored states.

Status System Commands

This section describes the structure of the SCPI status system for the Agilent 3499A/B/C and describes the commands used to work with the status system. The status system records various conditions, events, and states of the instrument in three register groups. The three groups are shown below.



Each register group has one or more low-level registers. These low-level registers are called condition, event, or enable registers and control the action of specific bits in the registers. You read or write to the registers using binary-weighted decimal numbers.

A *condition* register continuously monitors the state of the instrument. The bits in the condition register are updated in real time (they are not latched). The 3499A/B/C uses a condition register as a part of the Operation Status Register.

An *event* register latches events from the condition register. The 3499A/B/C has an event register as a part of the Operation Status Register and the Standard Event Register.

An *enable* register defines the bits in the event register that are reported to the Status Byte Register. You can read or write to an enable register.

You read and write to the Standard Event Register and Status Byte Register using IEEE488.2 common commands. The Operation Status Register uses SCPI commands.

You can read the status registers to determine the current operating state of the instrument. You can use a technique called *serial polling* to periodically read the Status Byte Register and determine the operating state of the instrument. You can also set the status system to generate an interrupt (on the GPIB SRQ line) when one or more specific events occur (called *SRQ interrupt*). Not all GPIB cards support SRQ enabled interrupts.

`*CLS`

This command clears all the event registers and the Status Byte register. It does not affect the enable registers. It also clears the error queue.

The Operation Status Register

The 3499A/B/C uses only three of the bits in this 16-bit register. Bit 0 indicates the instrument is waiting in the trigger layer (the next trigger event will advance the scan list). Bit 1 indicates the instrument is waiting in the arm layer (the next trigger event will move the instrument to the trigger layer). Bit 4 indicates a scan has started.

```
STATus
    :OPERation:CONDition?
```

Since the condition register is updated in real time, you will generally not use this register query. For example, bit 4 will never appear to be set since you cannot read the register at the time a scan starts.

```
STATus
    :OPERation[:EVENt]?
```

This query returns the binary weighted sum of the values in the event register. These bits are latched from the condition register and indicate that an event has occurred (at some time since the register was last cleared).

Sending this query clears all bits in the register.

```
STATus
    :OPERation:ENABle <unmask>
    :OPERation:ENABle?
```

These commands work with the enable register. The enable register is a mask used to determine which bits in the event register can be recorded in the OPR summary bit (bit 7) of the Status Byte register.

unmask can range from 0 to 16348, but is only applicable to the 3499A/B/C with the values 1, 2, and 16. For example sending:

```
STATus:OPERation:ENABle 16
```

sets the OPR summary bit in the Status Byte Register to be true (1) when a scan has started.

The query form of this command returns a decimal weighted value indicating the currently set bits in this register.

```
STATus
    :PRESet
```

This command clears the Operation Status Register enable register bits. All Enable bits are set to 0. This command does not affect the other register groups and does not clear the event register.

The Standard Event Register

The Standard Event Register reports instrument events, errors, and the `*OPC` command. The Standard Event Register reports through the ESB bit (bit 5) in the Status Byte Register.

`*ESR?`

This query returns a decimal weighted value of the event register. The values in this register are as follows:

Bit Number	Decimal Value	Definition
0 Power On	1	Power has been turned on since the last time the register was cleared (read).
1 Not Used	2	Returns “0”.
2 Command Error	4	A command syntax error occurred (error numbers in the -100 range).
3 Execution Error	8	An execution error occurred (error numbers in the -200 range).
4 Device Error	16	A self test error occurred (error numbers in the -300 range).
5 Query Error	32	An error during a query (error numbers in the -400 range).
6 Not Used	64	Returns “0”.
7 Operation Complete	128	All commands prior to and including *OPC have been executed.

`*ESE <unmask>`
`*ESE?`

These commands work with the enable register. The enable register is a mask used to determine which bits in the event register can be recorded in the ESB bit (bit 5) of the Status Byte Register.

unmask can range from 1 to 128. The query form of this command returns a decimal weighted value indicating the currently set bits in this register.

The Status Byte Register

The Status Byte Register reports conditions from the other register groups. Data in the 3499A/B/C output buffer is reported on the MAV bit (bit 4). If an event is cleared in one of the other registers, it is also cleared in the Status Byte register. The `*CLS` command clears the Status Byte register.

`*STB?`

This query reads the status byte. The returned value is a decimal-weighted summary of the bits in the register.

`*SRE <value>`
`*SRE?`

These commands work with the enable register. The enable register is a mask used to determine which bits in the event register can be summarized to the RQS bit (bit 6) of the Status Byte Register.

value can range from 1 to 128. The query form of this command returns a decimal-weighted value indicating the currently set bits in this register.

System Information Commands

These commands are used to obtain system-level information.

***IDN?**

This IEEE488.2 Common Command queries the instrument for the identification string. The returned string will contain the manufacturer identification, the model number, the serial number, and the firmware revision.

SYSTem:ERRor?

This query returns a variant of the instrument's error queue. Errors are retrieved in first-in-first-out (FIFO) order. The first error returned is the first error stored. See the "Error Messages" chapter on page 165 for the error numbers and messages.

Depending upon your programming environment, this query may return an integer containing the error number, or a variant containing the error number and error message.

When all the errors from the queue are read, the errors are cleared and the ERROR annunciator turns off. When the queue is empty, each following `SYSTem:ERRor?` query returns: `+0, "No error"`. To clear all error numbers/messages in the queue, execute the `*CLS` command or power-on the instrument.

The queue holds a maximum of 10 error number/message pairs. If the queue overflows, the last error number/message in the queue is replaced by: -350, "Queue overflow". The least recent error numbers/messages remain in the queue, and the most recent are discarded.

SYSTem:VERSion?

This query returns a string indicating the SCPI version implemented on the mainframe control board. The string is in the form: "Version A.02.00"

SYSTem:CTYPE? <*slot*>

This query returns a string containing the module identification in the specified slot. The *slot* parameter is a decimal ranging from 0 to 9 (mainframe dependent). Valid slot numbers are:

3499A	slots 0 through 5
3499B	slots 0 through 2
3499C	slots 0 through 9

The string returned has one of the following forms:

Module	Returned String	
Empty Slot	NO CARD	00000
Mainframe	Built-in DIO	3499, Serial #
N2260A	40CH MUX	N2260A, Serial #
N2261A	40CH GP	N2261A, Serial #
N2262A	4X8 MATRIX	N2262A, Serial #
N2263A	32BIT DIO	N2263A, Serial #
N2264A	12+3 (5A) CH GP+16BIT DIO	N2264A, Serial #
N2265A	4X4 MATRIX +16BIT DIO	N2265A, Serial #
N2266A	20CH MUX	N2266A, Serial #
N2267A	8(8A)CH GP	N2267A, Serial #
N2268A	DUAL 1X4 RF MUX	N2268A
N2270A	10(1000V)CH MUX	N2270A, Serial #
N2272A	RF MUX	N2272A
N2276A/B	Dual MICROWV MUX	N2276A/B, Serial #
N2280A	QUAD 1X2 OPTICAL	N2280A, Serial #
N2281A	DUAL 1X4 OPTICAL	N2281A, Serial #
N2282A	1X8 OPTICAL MUX	N2282A, Serial #
44470A	RELAY MUX	44470[a]
44470D	RELAY MUX	44470[a]
44471A	GP RELAY	44471[b]
44471D	GP RELAY	44471[b]
44472A	VHF SW	44472[c]
44473A	MATRIX SW	44473
44474A	DIGITAL IO	44474
44475A	BREADBOARD	44475
44476A/B	GP RELAY	44471[b]
44477A	GP RELAY	44471[b]
44478A/B	VHF SW	44472[c]

a. Both the 44470A/D return “RELAY MUX 44470”. You must physically check the module to determine which one is present.

b. All the 44471A/D, 44476A/B and 44477A return “GP RELAY 44471”. To determine if the module is an 44471A/D, 44476A/B or 44477A, check the switching channels. For 44471A/D and 44476A/B, you must physically check the modules to determine which one is present.

c. Both the 44478A/B return “VHF SW 44472”. You must physically check the module to determine which one is present.

DIAGnostic
[:RELay]:CYCLes? <*channel_list*>
[:RELay]:CYCLes:MAX? <*slot*>
[:RELay]:CYCLes:CLEar <*channel_list*>

The switching plug-in modules count the number of cycles on each relay on the module and store this total count in non-volatile memory on each switch module. Use this feature to track relay failures and predict system maintenance requirements.

This feature is supported by the Agilent N2260A, N2261A, N2262A, N2264A, N2265A, N2266A, N2267A, N2268A, N2270A, N2272A, N2276A, and N2280A/81A/82A modules.

The *channel_list* parameter has the form *@snn,* where *s* is the slot number and *nn* is the channel number. The actual channel numbers are module dependent. Channel number for plug-in modules are listed on page 70. The parameter can contain one or more channels as follows:

- a single channel, use (@snn);
- multiple channels, use (@snn,snn...);
- sequential channels, use (@snn:snn);
- groups of sequential channels, use (@snn:snn,snn:snn);
- or any combination of the above.

The *channel_list* parameter may also contain the tree switching relays (numbered as *s*98 and *s*99) for the N2260A and N2266A modules.

The `DIAGnostic:RELay:CYCLes?` query returns the number of cycles for the specified channel or channels. For modules or channels that cannot respond to the query, -1 is returned. For multiple channels, the returned value is a series of comma-separated integers in the same order as the *channel_list*.

The `DIAGnostic:RELay:CYCLes:MAX?` query returns the maximum relay cycle count for a module in the specified slot. The returned integer value is the maximum relay cycle count among all the relays on the specified module. The returned value does not indicate the channel number with the maximum count.

The `DIAGnostic[:RELay]:CYCLes:CLEar` command resets the relay cycle counter of the specified channel(s). This command resets the relay cycle count back to zero. Use this command when replacing a relay with a new one.

System-Level Control Commands

These commands allow you to synchronize the instrument to the bus controller, reset the instrument, and control the display.

***OPC**
***OPC?**

This command and query are used to synchronize the instrument with the bus controller. Use the `*OPC` command to set the bit in the Standard Event Register (see page 151) if you are using the SCPI status system. The bit is set when the command has finished executing.

Use the `*OPC?` query to synchronize the instrument with the bus controller without using the SCPI status system. Append the query to a command. The instrument returns a +1 in response to the query. For example, if you send:

```
ROUTe:CLOSe (@101);*OPC?
```

the instrument will return a +1 when the command has finished executing. Note that if you use this on a scan command, the return will not happen until the scan is complete (and depending upon your bus controller and the length of the scan list, may cause a time-out).

***RST**

This command resets the instrument and returns parameters to their default settings. System memory is cleared, digital configuration returns to the default state, and the error queue is cleared. Refer to page 74 for a complete list of the reset conditions.

***TST?**

This query begins a self-test and returns a code to indicate the test status. One of the following codes can be returned:

Returned Value	Meaning
+ 0	all tests have passed.
+ 1	ROM test failed.
+ 2	GPIB test failed.
+ 3	RS-232 test failed.
+ 4	front-panel test failed.

Note that the self test requires several seconds to run. This query will 'hang' the bus until the self test completes.

SYSTem:CPON <*slot*|ALL>

This command resets a specific module or all modules in the mainframe. This command will open all switching channels on a module or set all digital I/O ports to input ports. This command has no affect on card pairing or scan configurations.

You can use this command to return a specific module to the power on state. Unlike the `*RST` command, this command will not reset the mainframe (changing scan lists, scan configurations, digital I/O configurations, or card pairing).

```
DIAGnostic
    :DISPlay[:INFOrmation] <message>
    :DISPlay:STATe <0|1|OFF|ON>
    :DISPlay:STATe?
```

These commands control the front-panel display.

The `DIAGnostic:DISPlay:INFOrmation` command is used to write messages to the display. The *message* parameter is a string that can contain up to 13 characters. You can enter the string in lower case characters, but the display only shows upper case characters. In addition, each character (except the 13th) can be trailed by any one of four special characters (, . : ;). These "trailer" special character are not counted as one of the thirteen characters. Valid characters include:.

Type	Supported Characters
Numeric	0-9
Alphabetic	A-Z
Symbolic	" ' (space) ( ) * + - , . : ; / \

The `DIAGnostic:DISPlay:STATe` command turns the front-panel display on or off. The **ADRS**, **RMT**, and **ERROR** annunciators may turn on even when the front-panel display is turned off. After an instrument power-on or a reset command (`*RST`), the display will be turned on.

The `DIAGnostic:DISPlay:STATe?` query returns the display status. The returned value is either a "0" or a "1", indicating the display is turned off or on, respectively.

DIAGnostic
:MONitor <*slot*>|<*channel*>|<*port*>|-1
:MONitor?

The DIAGnostic:MONitor command enables the monitor mode for a plug-in module, channel, or port on the specified module. Send the -1 value to disable the monitor mode. Only one slot, one channel, or one port can be monitored each time. More information about monitoring is given on page 80.

For the built-in 4-bit Digital I/O, you may monitor the port (090) or bits (091 to 094). For the plug-in DIO modules, you may only monitor the 8-bit ports.

The Tree Relays (s98, s99) on an N2260A or N2266A cannot be monitored.

The monitor is disabled after an instrument power-on or a reset command.

The DIAGnostic:MONitor? query returns the slot, channel, or port being monitored. The returned value will be a valid slot number or channel address. A "-1" is returned if monitor is inactive.

SYSMODE <0|1|SCPI|HP3488>
SYSMODE?

The 3499A/B/C can be operated in either one of the two system modes: SCPI mode and 3488A mode. The SYSMODE command specifies the system mode to use. Changing the mode will reset the 3499A/B/C (see page 74), but the RS232 or GPIB settings will not be affected.

If you change modes with this command, you must allow a minimum 5 second interval before performing other operations.

The SYSMODE? query returns a string containing either "SCPI" or "HP3488A".

For information about the 3488 programming mode please visit www.agilent.com.

RS-232 Commands

These commands only apply to operations with the RS-232 interface.

```
SYSTem
    :LOCal
    :REMote
    :RWLock
```

The `SYSTem:LOCal` command sets the local mode for RS-232 operation. All keys on the front-panel are fully functional in this mode.

The `SYSTem:REMote` command sets the instrument to the remote mode for RS-232 operation. All keys on the front-panel, except **Local**, **View**, **Mon**, **Enter**, the knob, and the two arrow keys, are disabled.

When the 3499A/B/C has been addressed to listen, the **RMT** and **ADRS** annunciators turn on to indicate the instrument is in the Remote mode. The **ERROR** annunciator turns on whenever an error occurs.

The `SYSTem:RWLock` command sets the instrument to the remote mode of operation. All keys on the front-panel are disabled in this mode. This command is the same as the `SYSTem:REMote` command except that ***all*** keys on the front-panel are disabled.

About the SCPI Language

Common Commands

The IEEE 488.2 standard defines the common commands that perform functions such as reset, self-test, status byte query, and so on. Common commands are four or five characters in length, always begin with an asterisk (*), and may include one or more parameters. The command keyword is separated from the first parameter by a space character. Some examples of common commands are shown below:

```
*RST            *ESE 32          *STB?
```

SCPI Command Format

The SCPI commands perform functions like closing/opening switches, making measurements, querying instrument states or retrieving data. A subsystem command structure is a hierarchical structure that usually consists of a top level (or root) command, one or more lower level commands, and their parameters. The following example shows part of a typical subsystem:

```
[ROUTe:]
    CLOSe <channel_list>
    SCAN <scan_list>
    SCAN:SIZE?
```

`[ROUTe:]` is the root command, `CLOSe` and `SCAN` are second level commands with parameters, and `:SIZE?` is a third level command.

Command Separator

A colon (:) always separates a command from the next lower level command, as shown below:

```
ROUTe:SCAN:SIZE?
```

Colons separate the root command from the second level command (`ROUTe:SCAN`) and the second level from the third level (`SCAN:SIZE?`).

Abbreviated Commands

The command syntax shows most commands as a mixture of upper and lower case letters. The upper case letters indicate the abbreviated spelling for the command. For shorter program lines, send the abbreviated form. For better program readability, you may send the entire command. The instrument will accept either the abbreviated or the entire command.

For example, if the command syntax shows `CHANnel`, then `CHAN` and `CHANNEL` are both acceptable forms. Other forms of `CHANnel`, such as `CHANN` or `CHANNE` will generate an error. You may use upper or lower case letters. Therefore, `CHANNEL`, `channel`, and `ChAnNeL` are all acceptable.

Implied Commands

Implied commands are those which appear in square brackets ([ ]) in the command syntax. (Note that the brackets are not part of the command and are not sent to the instrument.) Suppose you send a second level command but do not send the preceding implied command. In this case, the instrument assumes you intend to use the implied command and it responds as if you had sent it. Examine the partial `[ROUTe:]` subsystem shown below:

```
[ROUTe:]CLOSe <channel_list>
    CLOSe? <channel_list>
    SCAN <scan_list>
    [:LIST]
    :SIZE?
```

The root command `[ROUTe:]` is an implied command. To close relays in a channel list, you can send either of the following command statements:

```
ROUT:CLOS (@100:107, 201, 205)
    or
CLOS (@100:107, 201, 205)
```

These commands function the same: closing Channels 0 through 7 in Slot 1 and Channels 1 and 5 in Slot 2.

Parameters

These are parameter types used with the SCPI language:

Parameter Type	Description
Numeric	Accepts all commonly used decimal representations of number including optional signs, decimal points, and scientific notation. 123, 123E2, -123, -1.23E2, .123, 1.23E-2, 1.23000E-01. Special cases include MINimum, MAXimum, and DEFault.
Boolean	Represents a single binary condition that is either true or false. ON, OFF, 1, 0
Discrete	Selects from a finite number of values. These parameters use mnemonics to represent each valid setting. An example is the TRIGger:SOURce <*source*> command where *source* can be BUS, EXT, HOLD, or IMM.

Parameters shown within square brackets ([ ]) are optional. (Note that the brackets are not part of the command and are not sent to the instrument.) If you do not specify a value for an optional parameter, the instrument uses the default value. For example, consider the `ARM:COUNt?[<MIN|MAX>]` command. If you send the command without specifying a parameter, the present `ARM:COUNt` setting is returned. If you send the `MIN` parameter, the command returns the minimum count available. If you send the `MAX` parameter, the command returns the maximum count available. Be sure to place a space between the command and the parameter.

Linking Commands

To link IEEE 488.2 Common Commands with SCPI Commands, use a semicolon between the commands. For example:

```
*RST;CONF:EXT:OUTP ON  or  TRIG:SOUR HOLD;*TRG
```

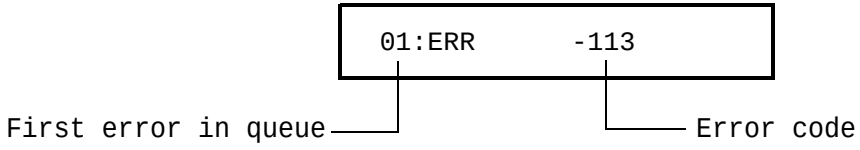
To link multiple SCPI commands, use both a semicolon and a colon between the commands. For example:

```
ARM:COUN 1;:TRIG:SOUR EXT
```

Error Messages

- Errors are retrieved in first-in-first-out (FIFO) order. The first error returned is the first error that was stored. Errors are cleared as you read them. When you have read all errors from the queue, the **ERROR** annunciator turns off and the errors are cleared. The instrument beeps once each time an error is generated.
- If more than 10 errors have occurred, the last error stored in the queue (the most recent error) is replaced with -350, "Queue overflow". No additional errors are stored until you remove errors from the queue. If no errors have occurred when you read the error queue, the instrument responds with +0, "No error".
- The error queue is cleared by the `*CLS` (clear status) command or when power is cycled. The errors are also cleared when you read the queue. The error queue is not cleared by an instrument reset (`*RST` command) or a card/module reset (`SYSTem:CPON` command).
- *Front-Panel Operation:*

  If the ERROR annunciator is on, press **View**, select **ERROR**, and press **Enter**. Use the knob to scroll through the error numbers. Press the arrow key (right) to view the text of the error message. All errors are cleared when you exit the menu.



- *Remote Interface Operation:*

  `SYSTem:ERRor?` Read and clear one error from the error queue.

  Errors have the following format (the error string may contain up to 80 characters):

  -113, "Undefined header"

Execution Errors

-101 **Invalid character**
An invalid character was found in the command string. You may have used an invalid character such as #, {, $, or % in the command header or within a parameter.
Example: `OPEN {@101)`

-102 **Syntax error**
Invalid syntax was found in the command string. You may have inserted a blank space before or after a colon in the command header, or before a comma. Or you may have omitted the "@" character in the channel list syntax.
Examples: `ROUT:CHAN: DEL 1` or `ROUT:OPEN ( 101:102)`

-103 **Invalid separator**
An invalid separator was found in the command string. You may have used a comma instead of a colon, semicolon, or blank space. You omitted a blank space between the SCPI command the first parameter.
Example: `TRIG:COUNT,1`

-105 **GET not allowed**
A Group Execute Trigger (`GET`) is not allowed within a command string.

-108 **Parameter not allowed**
More parameters were received than expected for this command. You may have entered an extra parameter or added a parameter to a command that does not require a parameter.
Example: `ROUT:CLOS:STAT? 2`

-109 **Missing parameter**
Fewer parameters were received than were expected for this command. You have omitted one or more parameters that are required for this command.
Example: `ROUT:CHAN:DEL 10,`

-112 **Program mnemonic too long**
A command header was received which contained more than the maximum 12 characters allowed.
Example: `CONFIGURE:EXTERNAL:TRIGGER:SOURCE 2`

-113 **Undefined header**
A command was received that is not valid for this instrument. You may have misspelled the command or it may not be a valid command. If you are using the short form of this command, remember that it may contain up to four letters.
Examples: `TRIGG:SOUR TIM`

-121 **Invalid character in number**
An invalid character was found in the number specified for a parameter.
Example: `TRIG:TIMER 12..34`

-123 **Exponent too large**
A numeric parameter was found whose exponent was large than 32,000.

-124 **Too many digits**
A numeric parameter was found whose mantissa contained more than 255 digits, excluding leading zeros.

-128 **Numeric data not allowed**
The wrong parameter type was found in the command string. You may have specified a number where a string or expression was expected, or vice versa.
Examples: `DISP:TEXT 5.0 or ROUT:CLOSE 101`

-131 **Invalid suffix**
A suffix was incorrectly specified for a numeric parameter. You may have misspelled the suffix.

-134 **Suffix too long**
A header suffix is the number that can be appended to the end of some command headers. This error is generated if the header suffix contains more than 12 characters.

-138 **Suffix not allowed**
A suffix was received following a numeric parameter. You may have misspelled the suffix.

-148 **Character data not allowed**
A discrete parameter was received but a character string or a numeric parameter was expected. Check the list of parameters to verify that you have used a valid parameter type.
Examples: `ROUTE:CLOSE CH101 or DIAG:DISP TEXT123`
(the string must be enclosed in quotes)

-151 **Invalid string data**
An invalid character string was received. Check to see if you have enclosed the character string in quotation marks and verify that the string contains valid ASCII characters.
Example: `DIAG:DISP 'TESTING` (the ending quote is missing)

-158 **String data not allowed**
A character string was received but is not allowed for this command. Check the list of parameters to verify that you have used a valid parameter type.

-161 **Invalid block data**
For a definite-length block, the number of types of data sent does not match the number of bytes that you specified in the block header

-168 **Block data not allowed**
Data was sent to the instrument in SCPI definite length block format but this command does not accept this format.

-178 **Expression data not allowed**
A channel list was received but is not allowed for this command.
Example: `SYST:CTYPE? (@100)`

-222 **Data out of range**
A numeric parameter value is outside the valid range for this command.
Example: `ARM:COUNT -3`

-223 **Too much data**
A character string was received but could not be executed because the string length was more than 13 characters. This error can be generated by the `DIAGnostic:DISPlay` command.

-224 **Illegal parameter value**
A discrete parameter was received which was not a valid choice for this command. You may have used an invalid parameter choice.
Example: `TRIG:SOURCE ALARM` (ALARM is not a valid choice)

-310 **System error**
A firmware defect has been found. This is not a fatal error but you should contact your nearest Agilent Technologies Service Center (see page 8) if this error is reported.

-350 **Queue overflow**
The error queue is full because more than 10 errors have occurred. No additional errors are stored until you remove errors from the queue. The error queue is cleared by the `*CLS` (clear status) command or when power is cycled. The errors are also cleared when you read the queue.

-410 **Query INTERRUPTED**
A command was received which sends data to the output buffer, but the output buffer contained data from a previous command (the previous data is not overwritten). The output buffer is cleared when power has been off or after a bus Device Clear.

-420 **Query UNTERMINATED**
The instrument was addressed to talk (i.e., send data over the interface) but a command has not been received which sends data to the output buffer. For example, you may have executed a `ROUTe` command (which does not generate data) and then attempted to read data from the remote interface.

-430 **Query DEADLOCKED**
A command was received which generates too much data to fit in the output buffer and the input buffer is also full. Command execution continues but all data is lost.

-440 **Query UNTERMINATED after indefinite response**
The `*IDN?` command must be the last query command within a command string. The `*IDN?` command returns an indefinite length string which cannot be combined with any other query command.
Example: `*IDN?;*STB?`

Instrument Errors

100 **Number of SAV/RCL out of range**
This error will occur if a number included in `*SAV` or `*RCL` is out of range. Up to 50 instrument setups can be stored using Firmware REV 4.0 (numbered 1 to 50). Up to 10 setups can be stored using Firmware REV 1.0/2.0/3.0 (numbered 1 to 10).
Examples: `*SAV 52` or `*RCL 0`

101 **Unable to recall - scan is running**

102 **Unable to recall - memory is empty**

103 **Unable to recall - modules were changed**
Before recalling a stored channel setup, the instrument verifies the same module types are installed in each slot. This error indicates that the instrument has detected one or more modules have been replaced with other module types or have been removed from the instrument.

104 **Unable to store - scan is running**

110 **Slot number out of range**
The specified slot number is invalid. The channel number has the form (@snn), where s is the slot number and nn is the channel number.
Example: `OPEN (@604)`

111 **Data out of range**
The data for some commands is invalid.
Example: `SOUR:DIG:DATA:BYTE:VAL 266` (valid data should be 0-255)

112 **Not able to perform requested operation**
The requested operation is not valid for the instrument.
Example: `FUNC 3,BIWIRE2` (the module in Slot 3 is not an N2260A).

113 **Block name not exist**
In the 3499A/B/C a maximum two blocks can be defined. The two defined blocks can be read and written, etc. If you read or write a block that has not been previously defined, this error occurs.

114 **Block name already exist**
The instrument has detected a defined block name, while you are to define it once more.

115 **Two Blocks already exist**
The instrument has detected two defined block names while you are to define them once more.

116 **Channel number out of range**
The specified channel number is invalid for the module in the selected slot. The channel number has the form (@*snn*), where *s* is the slot number and *nn* is the channel number.
Example: `ROUT:CLOSE (@156)`

201 **Scan list is empty**

202 **Scan initiated**

203 **Scan init ignored**

204 **Trig ignored**

205 **Hardware trigger too fast**

206 **Too many channels**

207 **Card in use**

208 **N2282A execution error**

300 **Unable to execute this command in local mode**

501 **RS232 data receiving error**

502 **Internal command error**

503 **RS232 only - unable to execute on GPIB**
There are three commands which are allowd only with the RS-232 interface:
`SYSTem:LOCal`, `SYSTem:REMote`, `SYSTem:RWLock`.

Self-Test Errors

The errors listed below indicate failures that may occur during a self-test (in SCPI mode).

Error Number	Description
+1	ROM test failed.
+2	GPIB test failed.
+3	RS-232 test failed.
+4	Front-panel test failed.

Note The string "+0" returned from a `*TST?` command indicates that all the tests have passed. In this case, "PASSED" displays on the front-panel of the instrument.

Plug-in Modules

Plug-in Modules

This chapter provides a general description, simplified schematic, and wiring information for each plug-in module. This chapter contains the following sections:

- N2260A 40-Channel MUX Module, on page 176
- N2261A 40-Channel GP Relay Module, on page 182
- N2262A 4 x 8 2-Wire Matrix Switch Module, on page 185
- N2263A 32-bit Digital I/O Module, on page 188
- N2264A Multifunction Module, on page 192
- N2265A Multifunction Module, on page 196
- N2266A 40-Channel MUX Module, on page 200
- N2267A 8-Channel High Current GP Module, on page 206
- N2268A 50Ω 3.0 GHz Dual 1-to-4 MUX Module, on page 210
- N2270A 10-Channel High Voltage MUX Module, on page 212
- N2272A 1 GHz RF 1-to-9 MUX Module, on page 214
- N2276A Dual 1-to-6(4) Microwave MUX/Attenuator Module, on page 217
- N2276B Microwave MUX/Attenuator Module, on page 221
- N2280A Quadruple 1-to-2 Optical Switch Module, on page 225
- N2281A Dual 1-to-4 Optical Switch Module, on page 226
- N2282A 1-to-8 Optical Switch Module, on page 228
- 44470A 10-Channel MUX Module, on page 230
- 44470D 20-Channel MUX Module, on page 233
- 44471A 10-Channel GP Relay Module, on page 236

- 44471D 20-Channel GP Relay Module, on page 239
- 44472A Dual 4-Channel VHF Switch Module, on page 242
- 44473A 4 x 4 2-Wire Matrix Switch Module, on page 245
- 44474A 16-Bit Digital I/O Module, on page 248
- 44475A Breadboard Module, on page 251
- 44476A Microwave Switch Module, on page 257
- 44476B Microwave Switch Module, on page 260
- 44477A Form-C Relay Module, on page 265
- 44478A/B 1.3 GHz Dual 4-to-1 MUX Modules, on page 267
- Protection Networks, on page 272
- Terminals and Connections Information, on page 275

Note You should not remove or install modules while the instrument is power on. If a module is accidentally removed or installed while the instrument power is on, the instrument will preform a reset. Reset conditions are described beginning on page 74.

N2260A 40-Channel MUX Module

The Agilent N2260A is a configurable multiplexer (MUX) module. It contains 40 2-wire latching relays for switching, and two non-latching tree relays for configuration.

The N2260A can be configured as:

- an 80-channel 1-wire multiplexer,
- a 40-channel 2-wire multiplexer (default),
- two independent, 20-channel 2-wire multiplexers, or
- a 20-channel 4-wire multiplexer.

These modes can be selected from the front-panel or with a SCPI command (see page 83).

An instrument power-on or reset will set the N2260A to its default configuration (as a 40-channel 2-wire MUX module).

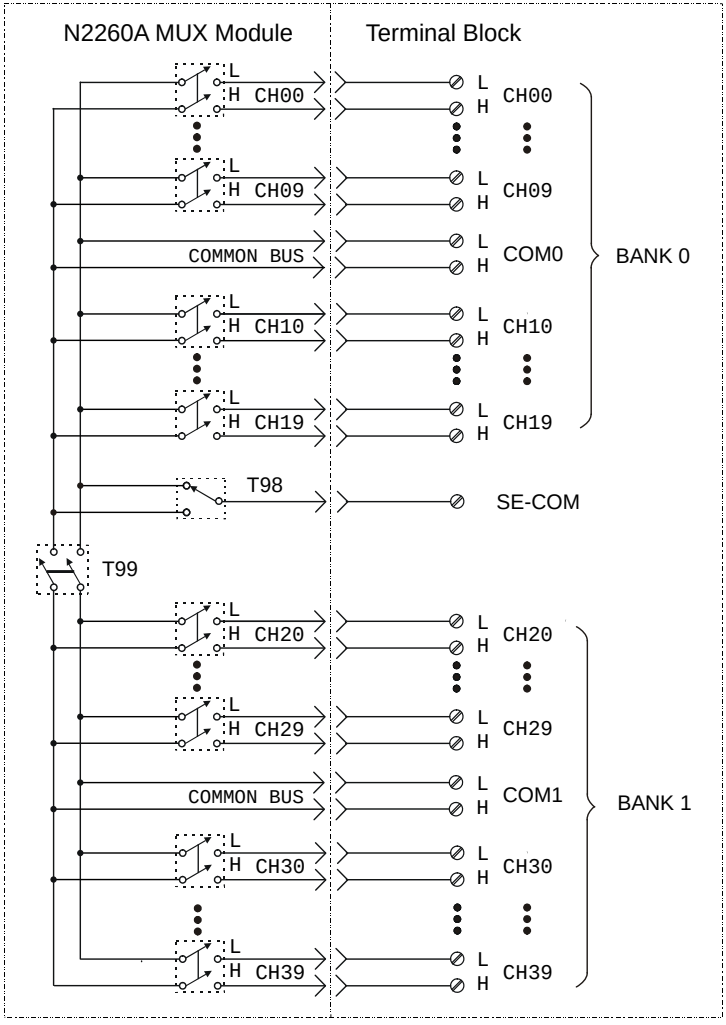
The N2260A can be operated in either SCPI mode or 3488A mode, but configuration is only possible in the SCPI mode. In 3488A mode, the N2260A can only be used as a 40-channel 2-wire MUX module.

A parallel switching feature makes the N2260A well suited for high speed switching. The 40 2-wire relays on the N2260A can be separated into four groups and up to 10 relays in the same group can be closed simultaneously (parallel switching). The groups are: group 1 (channel 00 through channel 09), group 2 (channel 10 through channel 19), group 3 (channel 20 through channel 29) and group 4 (channel 30 through channel 39). Additional information about parallel switching is given on page 84.

Specifications for the N2260A are given on page 303.

N2260A Simplified Schematic

A simplified schematic of the N2260A is shown below. The 40 2-wire channel relays (CH00-CH39) are divided into two banks: BANK 0 and BANK 1. Each bank consists of 20 2-wire switching channels and a common bus (COM0 & COM1). There is also a single-ended common terminal (SE-COM) used when the multiplexer is configured to 80-channel 1-wire mode. The two tree relays, T98 and T99, are used to configure the N2260A.



1-Wire Mode In this mode, either the High (H) or Lo (L) terminal of a channel is switched to the single-ended (SE-COM) terminal. The Lo terminals form the first 40 1-wire channels (00-39), and the Hi terminals form the second 40 1-wire channels (40-79). Only one channel can be closed at a time in the 1-wire mode.

2-Wire Mode This is the default mode of the N2260A and provides 40 2-wire channels. In this mode, the Hi and Lo terminals of a channel are switched to Hi and Lo common terminals (COM0 and COM1). The channels are numbered 00 through 39.

Dual 2-Wire Mode In this mode, the N2260A is separated into two independent banks (BANK 0 & BANK 1). Each bank consists of 20 2-wire channels and a corresponding common bus, COM0 and COM1. The channels in BANK 0 are numbered 00 through 19, and the channels in BANK 1 are numbered 20 through 39.

Note You must modify the PC board to use this mode of operation. The modification is described in the next section.

4-Wire Mode In this mode, the two banks (BANK 0 & BANK 1) are paired to form a 20-channel 4-wire multiplexer. The first channels of each bank (CH00 & CH20) form Channel 00, the second channels of the each bank (CH01 & CH21) form Channel 01, and so on.

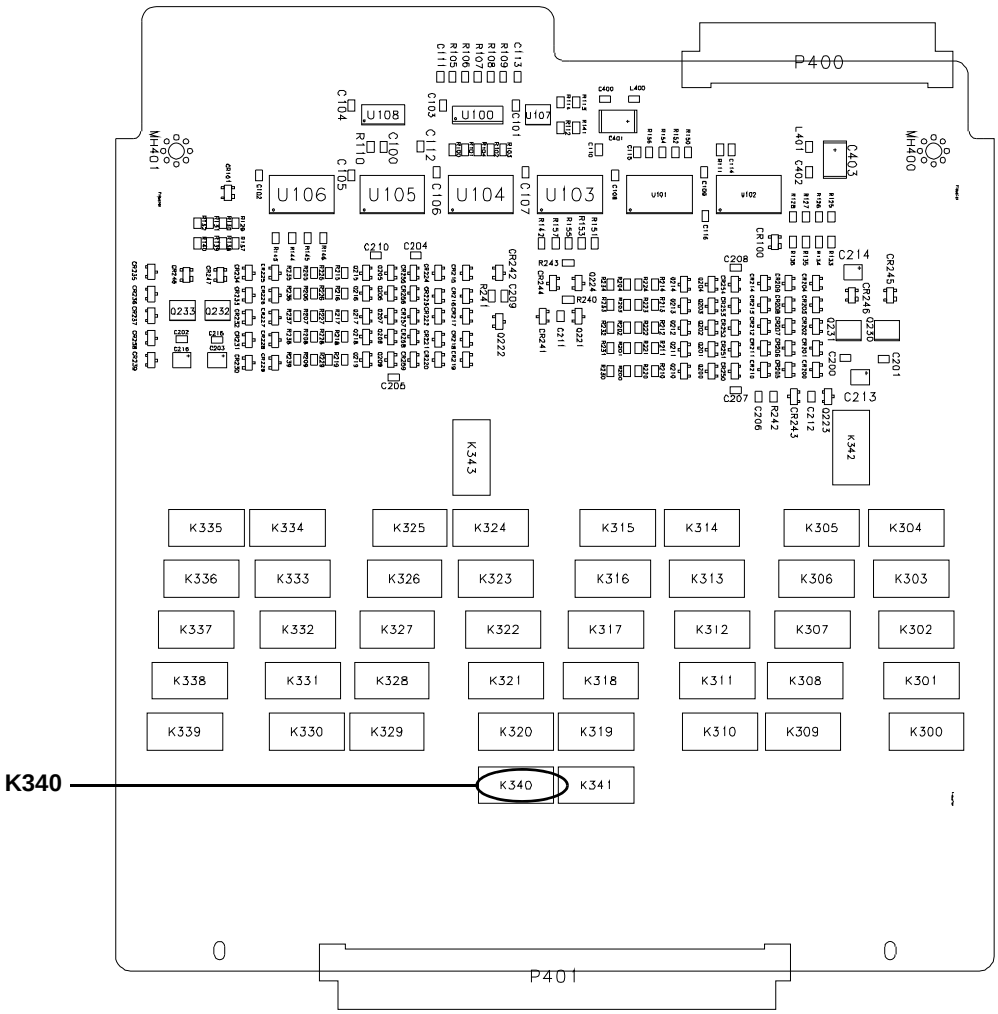
Note An instrument power-on or reset will set the N2260A to its default configuration as a 40-channel 2-wire MUX module.

Dual 2-Wire Mode - PC Board Modification

To operate the module in the Dual 2-wire mode, you must make modifications to the module's printed circuit board. Specifically, you must unsolder and remove relay T99. On the PC board, T99 has a reference designator of K340. The location of K340 is shown below.

Caution

You must use proper anti-static procedures, de-soldering techniques, and equipment to prevent damage to the PC board.

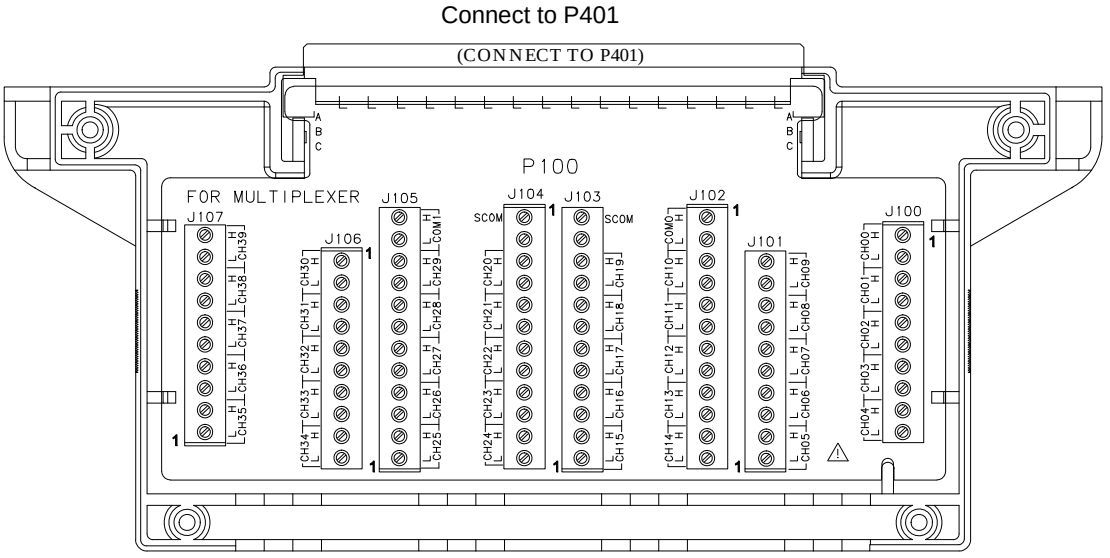


N2260A Wiring Information

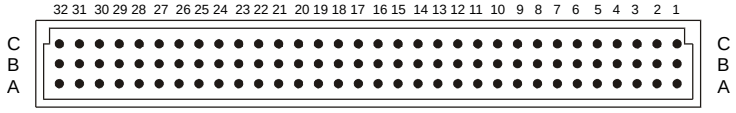
There are four methods available to connect to the N2260A:

- A screw terminal block, the N2290A (described on page 277).
- A direct wiring (insulation displacement) connector, the N2296A (described on page 278).
- A DIN96 to twin D50 Cable, the N2297A (described on page 279).
- A DIN96 to four D25 Cable, the N2299A (described on page 281).

The screw terminal block (N2290A) is shown below. To use the other connection options, you will need to use the module pinout information on page 181.



N2260A Pinout P401 is a 96-pin male DIN connector mounted on the N2260A. The connector and pin assignments are shown below.



View from the Pin Side of the Connector

Pin #	A	B	C	Pin #	A	B	C
1	CH0_L	CH1_L	CH2_L	**17**	CH20_L	CH21_L	CH22_L
2	CH0_H	CH1_H	CH2_H	**18**	CH20_H	CH21_H	CH22_H
3	CH3_L	CH4_L	CH5_L	**19**	CH23_L	CH24_L	CH25_L
4	CH3_H	CH4_H	CH5_H	**20**	CH23_H	CH24_H	CH25_H
5	CH6_L	CH7_L	CH8_L	**21**	CH26_L	CH27_L	CH28_L
6	CH6_H	CH7_H	CH8_H	**22**	CH26_H	CH27_H	CH28_H
7	CH9_L	Not used	COM0_L	**23**	CH29_L	Not used	COM1_L
8	CH9_H	Not used	COM0_H	**24**	CH29_H	Not used	COM1_H
9	CH10_L	CH11_L	CH12_L	**25**	CH30_L	CH31_L	CH32_L
10	CH10_H	CH11_H	CH12_H	**26**	CH30_H	CH31_H	CH32_H
11	CH13_L	CH14_L	CH15_L	**27**	CH33_L	CH34_L	CH35_L
12	CH13_H	CH14_H	CH15_H	**28**	CH33_H	CH34_H	CH35_H
13	CH16_L	CH17_L	CH18_L	**29**	CH36_L	CH37_L	CH38_L
14	CH16_H	CH17_H	CH18_H	**30**	CH36_H	CH37_H	CH38_H
15	CH19_L	Not used	SE-COM	**31**	CH39_L	Not used	Not used
16	CH19_H	Not used	SE-COM	**32**	CH39_H	Not used	Not used

N2261A 40-Channel GP Relay Module

The Agilent N2261A GP Relay Module contains 40 independent Single Pole - Single Throw (SPST, Form A) latching relays.

If necessary, you can pair two N2261A modules to provide 2-wire switching.

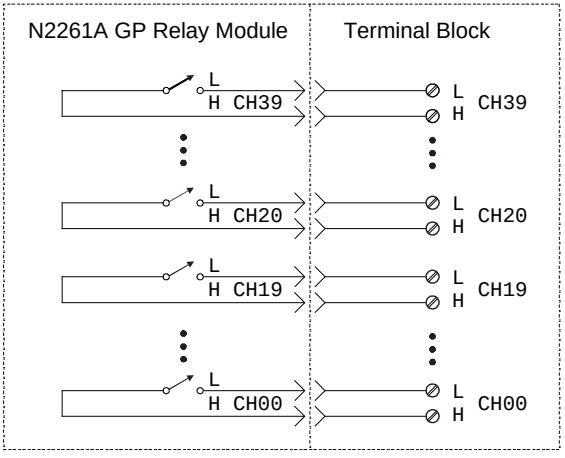
The N2261A can be operated in one of two modes: single channel break-before-make (BBM) or multiple channels in a closed position.

A parallel switching feature makes the N2261A well suited for high speed switching. The 40 2-wire relays on the N2261A can be separated into four groups and up to 10 relays in the same group can be closed simultaneously (parallel switching). The groups are: group 1 (channel 00 through channel 09), group 2 (channel 10 through channel 19), group 3 (channel 20 through channel 29) and group 4 (channel 30 through channel 39). Additional information about parallel switching is given on page 84.

Specifications for the Agilent N2261A are given on page 305.

N2261A Simplified Schematic

A simplified schematic is shown below. The N2261A contains 40 independent Single Pole-Single Throw (SPST, Form A) latching relays. A channel refers to an individual relay on the module. Channels are numbered 00 through 39 for the N2261A.

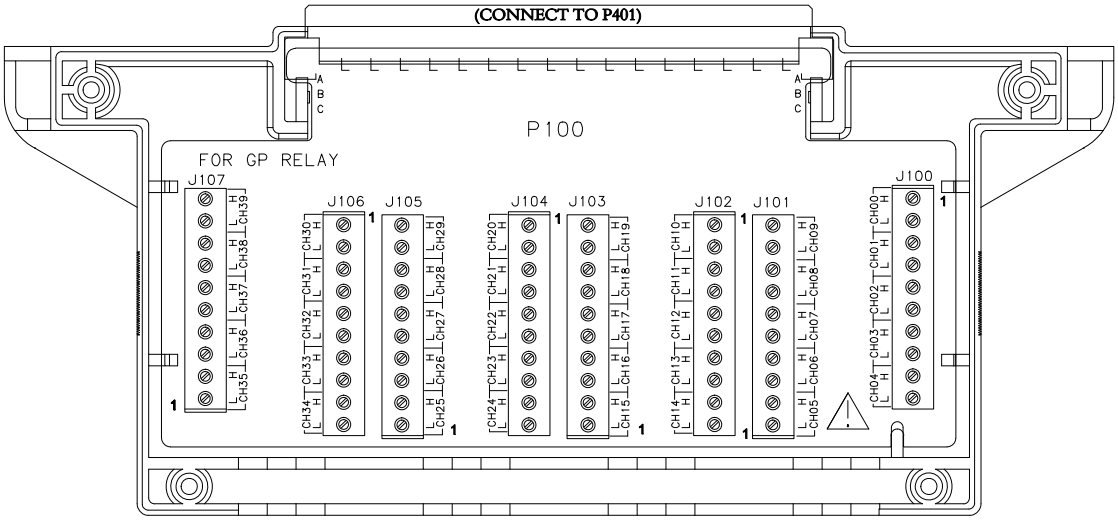


N2261A Wiring Information

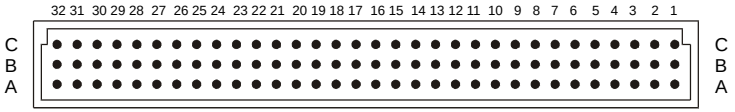
There are four methods available to connect to the N2261A:

- A screw terminal block, the N2291A (described on page 277).
- A direct wiring (insulation displacement) connector, the N2296A (described on page 278).
- A DIN96 to twin D50 Cable, the N2297A (described on page 279).
- A DIN96 to four D25 Cable, the N2299A (described on page 281).

The screw terminal block (N2291A) is shown below. To use the other connection options, you will need to use the pinout information on page 184.



N2261A Pinout P401 is a 96-pin male DIN connector mounted on the N2261A. The connector and pinout assignments are shown below.



View from the Pin Side of the Connector

Pin #	A	B	C	Pin #	A	B	C
1	CH0_L	CH1_L	CH2_L	**17**	CH20_L	CH21_L	CH22_L
2	CH0_H	CH1_H	CH2_H	**18**	CH20_H	CH21_H	CH22_H
3	CH3_L	CH4_L	CH5_L	**19**	CH23_L	CH24_L	CH25_L
4	CH3_H	CH4_H	CH5_H	**20**	CH23_H	CH24_H	CH25_H
5	CH6_L	CH7_L	CH8_L	**21**	CH26_L	CH27_L	CH28_L
6	CH6_H	CH7_H	CH8_H	**22**	CH26_H	CH27_H	CH28_H
7	CH9_L	Not used	Not used	**23**	CH29_L	Not used	Not used
8	CH9_H	Not used	Not used	**24**	CH29_H	Not used	Not used
9	CH10_L	CH11_L	CH12_L	**25**	CH30_L	CH31_L	CH32_L
10	CH10_H	CH11_H	CH12_H	**26**	CH30_H	CH31_H	CH32_H
11	CH13_L	CH14_L	CH15_L	**27**	CH33_L	CH34_L	CH35_L
12	CH13_H	CH14_H	CH15_H	**28**	CH33_H	CH34_H	CH35_H
13	CH16_L	CH17_L	CH18_L	**29**	CH36_L	CH37_L	CH38_L
14	CH16_H	CH17_H	CH18_H	**30**	CH36_H	CH37_H	CH38_H
15	CH19_L	Not used	Not used	**31**	CH39_L	Not used	Not used
16	CH19_H	Not used	Not used	**32**	CH39_H	Not used	Not used

N2262A 4 x 8 2-Wire Matrix Switch Module

The Agilent N2262A 4 x 8 Matrix module contains 32 2-wire nodes (crosspoints) organized in a 4-row by 8-column configuration. Each node in the matrix contains a 2-wire latching relay for switching both Hi (H) and Lo (L) terminals of a signal line. Multiple switches can be closed, allowing any combination of row-to-column connections.

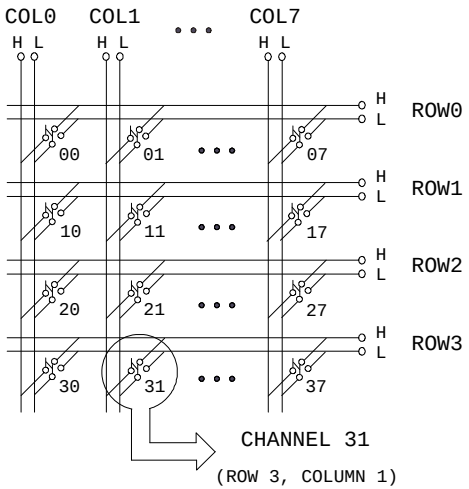
The parallel switching feature makes it well suited for high speed switching applications. Up to 8 2-wire node/crosspoint relays in the same row can be closed all at once (parallel switching).

The N2262A provides a convenient way to connect multiple test instruments to multiple test points on a device or to multiple devices. Multiple N2262A modules can be connected together, or used in conjunction with other modules such as the N2260A 40-Channel MUX to provide a wide variety of switching combinations.

Specifications for the Agilent N2262A are given on page 307.

N2262A Simplified Schematic

A simplified schematic is shown below. The N2262A contains 32 2-wire crosspoints organized in a 4-row by 8-column configuration. Each crosspoint relay has a unique two digit channel number *mn*, where *m* = row number (0-3) and *n* = column number (0-7).



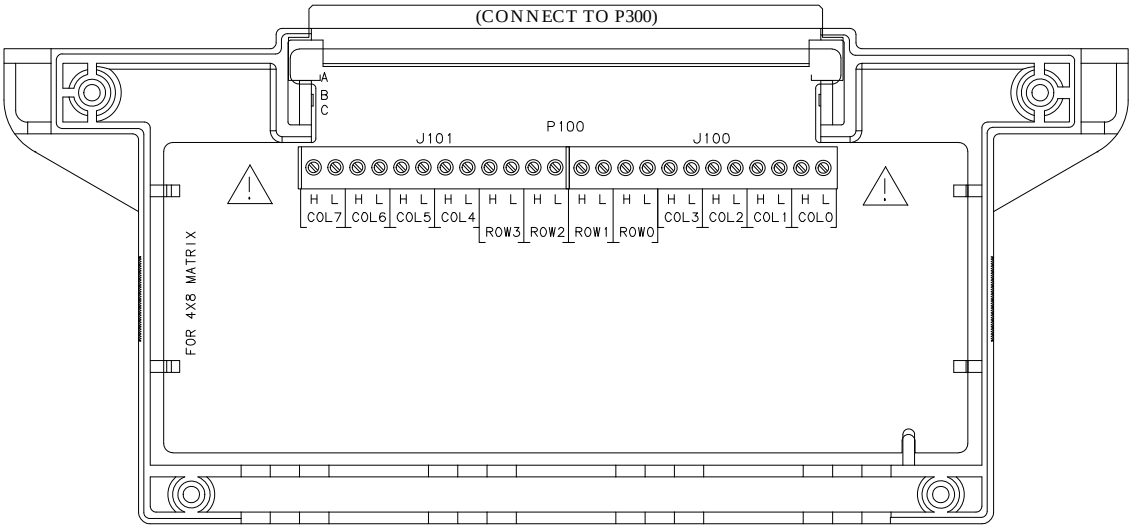
Channel 31 represents the relay at the crosspoint of Row 3 (ROW3) and Column 1 (COL1).

N2262A Wiring Information

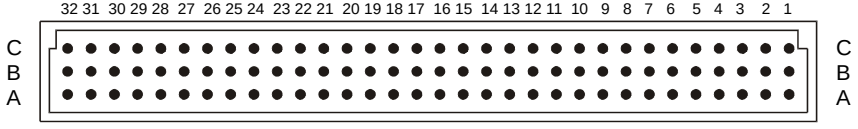
There are three methods available to connect to the N2262A:

- A screw terminal block, the N2292A (described on page 277).
- A direct wiring (insulation displacement) connector, the N2296A (described on page 278).
- A DIN96 to twin D25 Cable, the N2298A (described on page 280).

The screw terminal block (N2292A) is shown below. To use the other connection options, you will need to use the pinout information on page 187.



N2262A Pinout P300 is a 96-pin male DIN connector mounted on the N2262A. The connector and pinout assignments are shown below. Note that the A and B rows in the connector are not used.



View from the Pin Side of the Connector

Pin #	C	Pin #	C	Pin #	C	Pin #	C
1	COL0_L	**9**	Not used	**17**	Not used	**25**	COL4_L
2	COL0_H	**10**	ROW0_L	**18**	ROW2_L	**26**	COL4_H
3	COL1_L	**11**	ROW0_H	**19**	ROW2_H	**27**	COL5_L
4	COL1_H	**12**	Not used	**20**	Not used	**28**	COL5_H
5	COL2_L	**13**	Not used	**21**	Not used	**29**	COL6_L
6	COL2_H	**14**	ROW1_L	**22**	ROW3_L	**30**	COL6_H
7	COL3_L	**15**	ROW1_H	**23**	ROW3_H	**31**	COL7_L
8	COL3_H	**16**	Not used	**24**	Not used	**32**	COL7_H

N2263A 32-bit Digital I/O Module

The Agilent N2263A is a 32-bit digital I/O module. It provides 32 bidirectional data lines (bits) and 3 handshake lines (used for control and handshaking). All lines are TTL compatible. The 32 I/O bits can be addressed as 32 individual 1-bit ports, four independent 8-bit ports, two independent 16-bit ports, or one 32-bit port.

The four 8-bit ports are completely independent of each other and may be used separately. For example, two of the ports can be used for output operations, while the other two ports are used for input operations. However, all 8 bits in a given port must be either input or output bits (not a combination of input and output).

Five handshaking modes are available for this module. The handshaking modes are described beginning on page 98. Handshaking uses up to three control lines:

- Peripheral Control (PCTL)
- I/O direction (I/O)
- Peripheral Flag (PFLG)

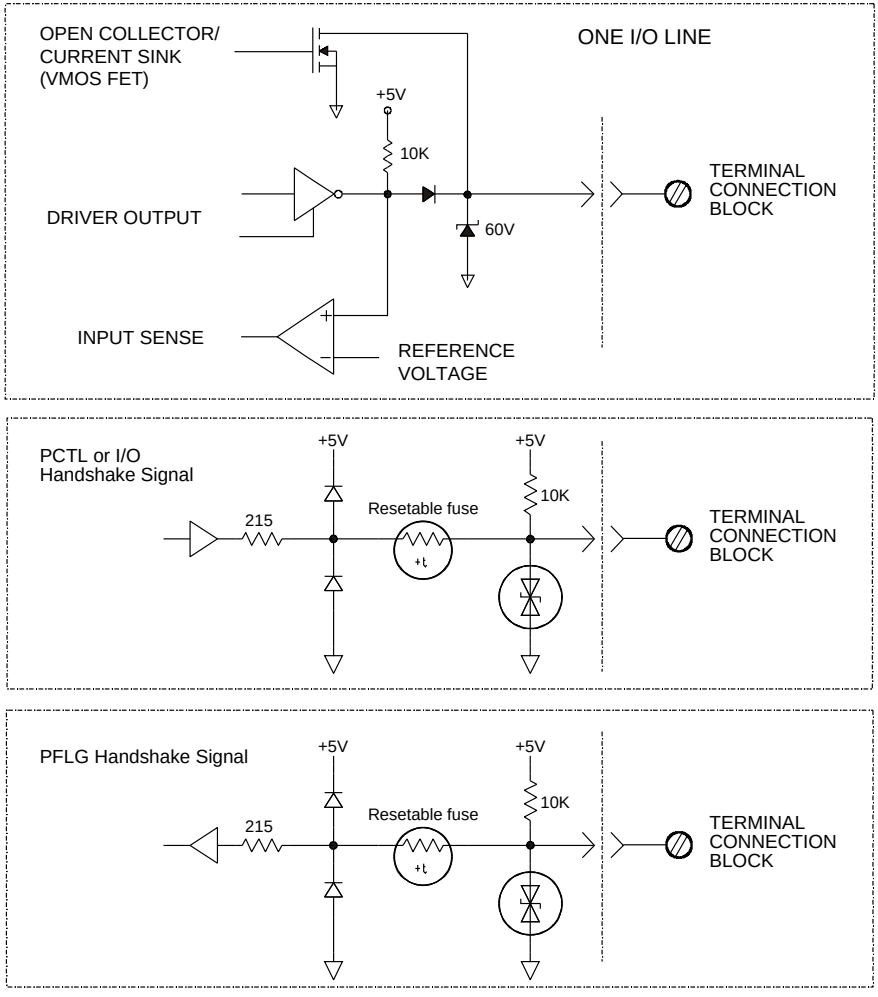
Port and bit numbering is show in the table below. Note that the ports are numbered differently if you are using the 3488 System mode.

System Mode	32-Bit Port #	16-Bit Port #	8-Bit Port #	Bit #
SCPI mode	PORT 00	PORT 00	PORT 00	Bits 0-7
			PORT 01	Bits 8-15
		PORT 02	PORT 02	Bits 16-23
			PORT 03	Bits 24-31
3488A Mode	PORT 06	PORT 04	PORT 00	Bits 0-7
			PORT 01	Bits 8-15
		PORT 05	PORT 02	Bits 16-23
			PORT 03	Bits 24-31

Specification for the N2263A are given on page 309.

N2263A Simplified Schematic

The N2263A consists of 32 bidirectional I/O channels, each of which includes digital in and digital out circuits as shown in the simplified schematic below. Each input has its own pull-up resistor, allowing easy detection of external termination (grounded or open-circuited) status. Each output driver is capable of sinking an externally-supplied current up to 600 mA, making it possible to control relays without the need for additional driver circuitry.

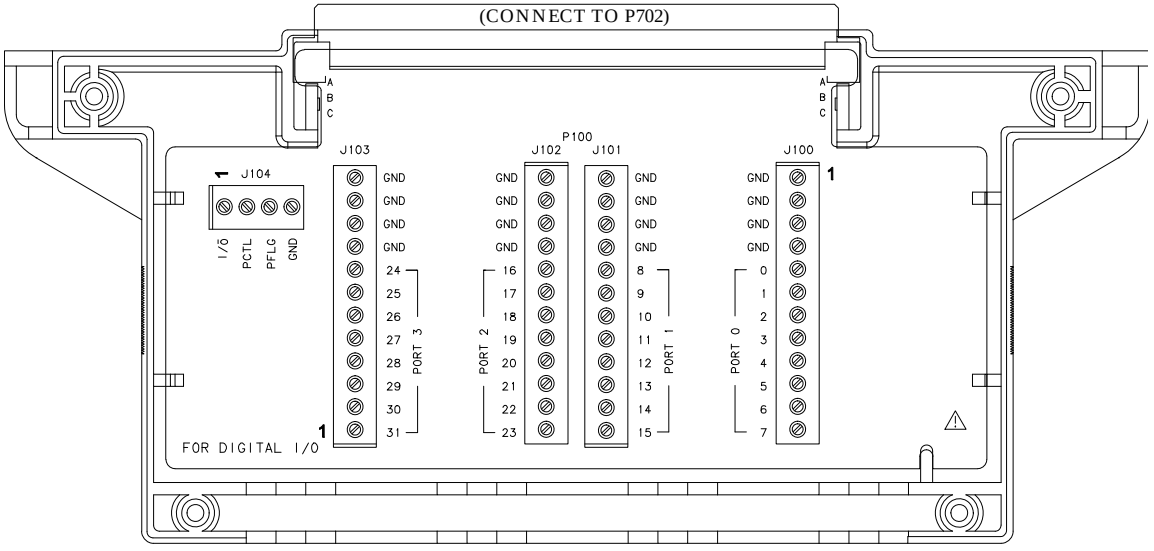


N2263A Wiring Information

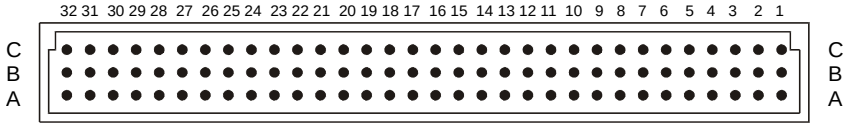
There are four methods available to connect to the N2263A:

- A screw terminal block, the N2293A (described on page 277).
- A direct wiring (insulation displacement) connector, the N2296A (described on page 278).
- A DIN96 to twin D50 Cable, the N2297A (described on page 279).
- A DIN96 to four D25 Cable, the N2299A (described on page 281).

The screw terminal block (N2293A) is shown below. To use the other connection options, you will need to use the pinout information on page 191.



N2263A Pinout P702 is a 96-pin male DIN connector mounted on the N2263A. The connector and pinout assignments are shown below.



View from the Pin Side of the Connector

Pin #	A	B	C	Pin #	A	B	C
1-2	Not used	Not used	Not used	**19**	BIT16	BIT17	BIT18
3	BIT0	BIT1	BIT2	**20**	GND	GND	GND
4	GND	GND	GND	**21**	BIT19	BIT20	BIT21
5	BIT3	BIT4	BIT5	**22**	GND	GND	GND
6	GND	GND	GND	**23**	BIT22	BIT23	GND
7	BIT6	BIT7	GND	**24**	GND	GND	GND
8	GND	GND	GND	**25**	BIT24	BIT25	BIT26
9	BIT8	BIT9	BIT10	**26**	GND	GND	GND
10	GND	GND	GND	**27**	BIT27	BIT28	BIT29
11	BIT11	BIT12	BIT13	**28**	GND	GND	GND
12	GND	GND	GND	**29**	BIT30	BIT31	GND
13	BIT14	BIT15	GND	**30**	GND	GND	GND
14	GND	GND	GND	**31**	I/O	PCTL	PFLG
15-18	Not used	Not used	Not used	**32**	GND	GND	GND

N2264A Multifunction Module

The Agilent N2264A multifunction module combines a GP relay function, a high-current GP relay function, and a digital input/output function on a single module. It consists of:

- 12-Channel GP relays (non-latching Form-A)
- 3-Channel High-current GP relays (non-latching Form-A), capable of switching up to 5 amps.
- 16-bit Digital I/O

The parallel switching feature makes the module well suited for high speed switching applications. Any 10 of the 15 GP relays on the N2264A can be closed all at once (parallel switching). Additional information about parallel switching is given on page 84.

Five handshaking modes are available for the digital I/O function. The handshaking modes are described beginning on page 98. Handshaking uses up to three control lines:

- Peripheral Control (PCTL)
- I/O direction (I/O)
- Peripheral Flag (PFLG)

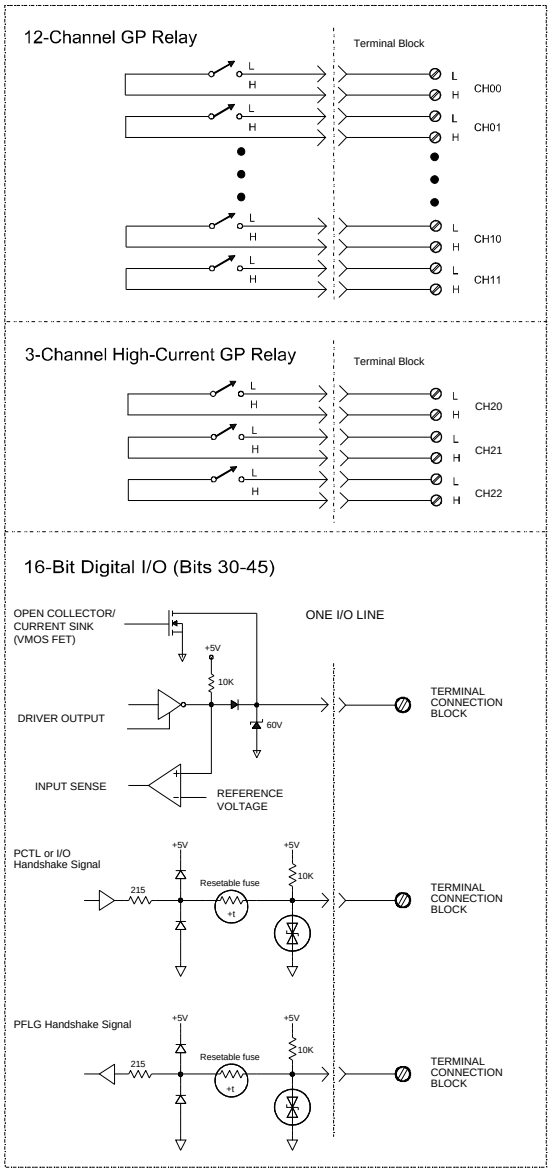
Port and bit numbering is show in the table below. Note that the ports are numbered differently if you are using the 3488 System mode.

Operating Mode	16-Bit Port #	8-Bit Port #	Bit #
SCPI mode	PORT 30	PORT 30	Bits 30-37
		PORT 31	Bits 38-45
3488A Mode	PORT 32	PORT 30	Bits 30-37
		PORT 31	Bits 38-45

Specifications for the N2264A are given on page 310.

N2264A Simplified Schematic

A simplified schematic is shown below. There are three independent functions on the N2264A: the 12-channel GP Relay (CH00-11), the 3-channel High-current GP Relay (CH20-22), and the 16-bit Digital I/O (bits 30-45).

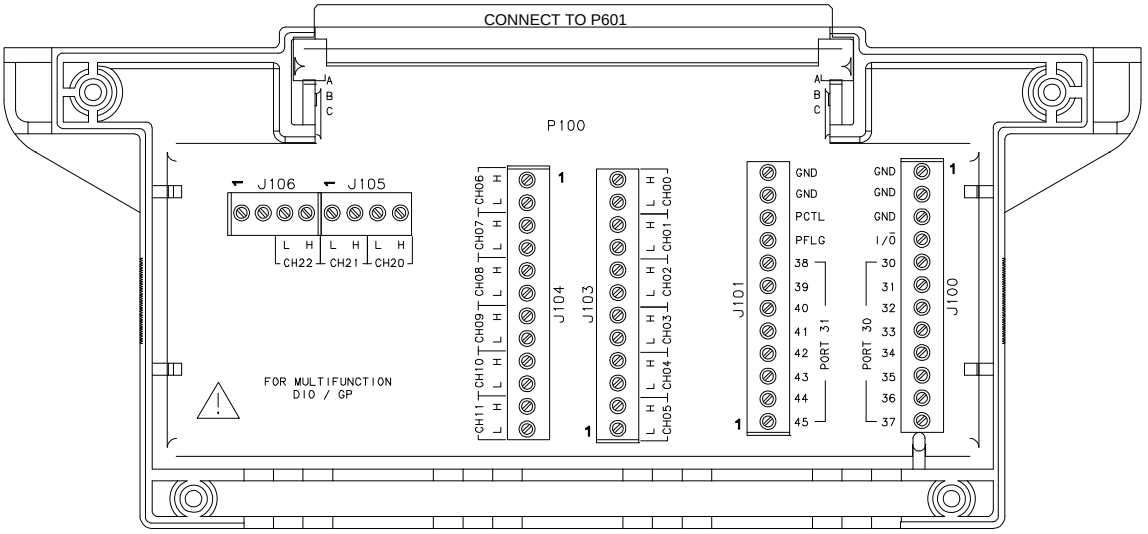


N2264A Wiring Information

There are four methods available to connect to the N2264A:

- A screw terminal block, the N2294A (described on page 277).
- A direct wiring (insulation displacement) connector, the N2296A (described on page 278).
- A DIN96 to twin D50 Cable, the N2297A (described on page 279).
- A DIN96 to four D25 Cable, the N2299A (described on page 281).

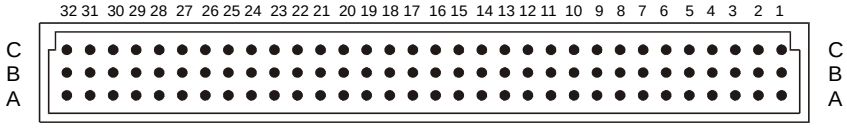
The screw terminal block (N2294A) is shown below. To use the other connection options, you will need to use the pinout information given on page 195.



Caution

12 pins (6 H and 6 L) are provided for each channel of the 3-Channel High-current GP Relay. Make sure to use ALL 12 pins whenever the switched current exceeds 1 amp.

N2264A Pinout P601 is a 96-pin male DIN connector mounted on the N2264A. The connector and pinout assignments are shown below.



View from the Pin Side of the Connector

Pin #	A	B	C	Pin #	A	B	C
1	BIT30	BIT31	BIT32	**17**	CH6_L	CH7_L	CH8_L
2	GND	GND	GND	**18**	CH6_H	CH7_H	CH8_H
3	BIT33	BIT34	BIT35	**19**	CH9_L	CH10_L	CH11_L
4	BIT36	BIT37	GND	**20**	CH9_H	CH10_H	CH11_H
5	GND	GND	GND	**21**	CH20_L	CH20_L	CH20_L
6	BIT38	BIT39	BIT40	**22**	CH20_L	CH20_L	CH20_L
7	GND	GND	GND	**23**	CH20_H	CH20_H	CH20_H
8	BIT41	BIT42	BIT43	**24**	CH20_H	CH20_H	CH20_H
9	BIT44	BIT45	GND	**25**	CH21_L	CH21_L	CH21_L
10	I/O	PCTL	PFLG	**26**	CH21_L	CH21_L	CH21_L
11	GND	GND	GND	**27**	CH21_H	CH21_H	CH21_H
12	Not used	Not used	Not used	**28**	CH21_H	CH21_H	CH21_H
13	CH0_L	CH1_L	CH2_L	**29**	CH22_L	CH22_L	CH22_L
14	CH0_H	CH1_H	CH2_H	**30**	CH22_L	CH22_L	CH22_L
15	CH3_L	CH4_L	CH5_L	**31**	CH22_H	CH22_H	CH22_H
16	CH3_H	CH4_H	CH5_H	**32**	CH22_H	CH22_H	CH22_H

N2265A Multifunction Module

The Agilent N2265A is a multifunction module which consists of:

- A 4 x 4 2-wire Matrix module (16 latching relays) and;
- A 16-bit digital I/O module.

The parallel switching feature makes the matrix portion of this module well suited for high-speed switching applications. Up to eight 2-wire node/crosspoint relays in the same row can be closed all at once (parallel switching). Additional information about parallel switching is given on page 84.

Five handshaking modes are available for the digital I/O function. The handshaking modes are described beginning on page 98. Handshaking uses up to three control lines:

- Peripheral Control (PCTL)
- I/O direction (I/O)
- Peripheral Flag (PFLG)

Port and bit numbering is show in the table below. Note that the ports are numbered differently if you are using the 3488 System mode.

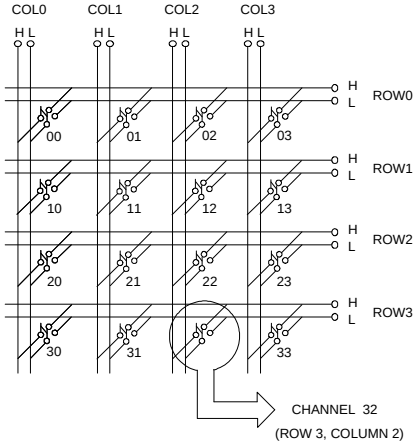
Operating Mode	16-Bit Port #	8-Bit Port #	Bit #
SCPI mode	PORT 40	PORT 40	Bits 40-47
		PORT 41	Bits 48-55
3488A Mode	PORT 42	PORT 40	Bits 40-47
		PORT 41	Bits 48-55

Specifications for the N2265A are shown on page 313.

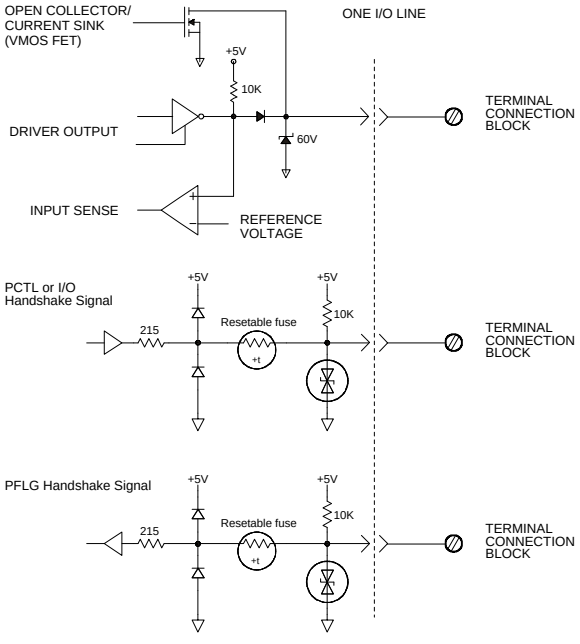
N2265A Simplified Schematic

A simplified schematic of the N2265A is shown on the next page. The N2265A is separated into two sections: the 4 x 4 2-wire matrix and the 16-bit digital I/O. A channel on the N2265A refers to an individual crosspoint on the matrix, or an individual bit on the 16-bit digital I/O.

4 x 4 2-Wire Matrix



16-Bit Digital I/O (Bits 40-55)

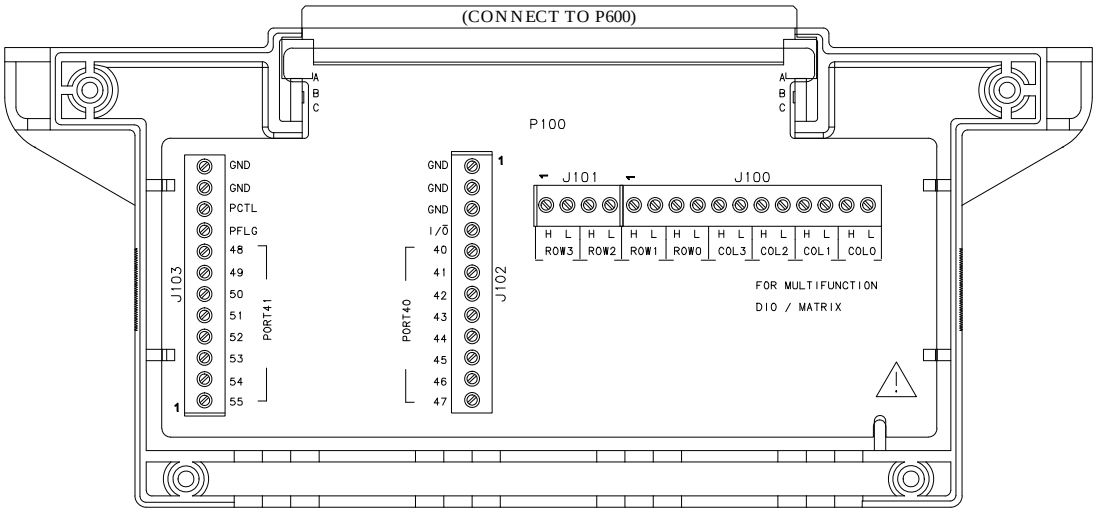


N2265A Wiring Information

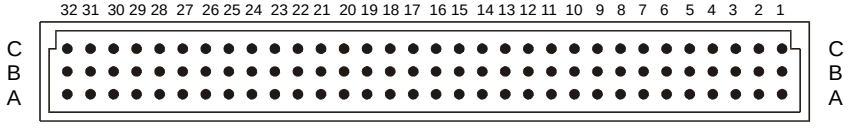
There are four methods available to connect to the N2265A:

- A screw terminal block, the N2295A (described on page 277).
- A direct wiring (insulation displacement) connector, the N2296A (described on page 278).
- A DIN96 to twin D50 Cable, the N2297A (described on page 279).
- A DIN96 to four D25 Cable, the N2299A (described on page 281).

The screw terminal block (N2295A) is shown below. To use the other connection options, you will need to use the pinout information on page 199.



N2265A Pinout P600 is a 96-pin male DIN connector mounted on the N2265A. The connector and pinout assignments are shown below.



View from the Pin Side of the Connector

Pin #	A	B	C	Pin #	A	B	C
1	Not used	Not used	COL0_L	**17**	Not used	Not used	Not used
2	Not used	Not used	COL0_H	**18**	Not used	Not used	Not used
3	Not used	Not used	COL1_L	**19**	BIT40	BIT41	BIT42
4	Not used	Not used	COL1_H	**20**	GND	GND	GND
5	Not used	Not used	COL2_L	**21**	BIT43	BIT44	BIT45
6	Not used	Not used	COL2_H	**22**	GND	GND	GND
7	Not used	Not used	COL3_L	**23**	BIT46	BIT47	GND
8	Not used	Not used	COL3_H	**24**	GND	GND	GND
9	Not used	Not used	ROW0_L	**25**	BIT48	BIT49	BIT50
10	Not used	Not used	ROW0_H	**26**	GND	GND	GND
11	Not used	Not used	ROW1_L	**27**	BIT51	BIT52	BIT53
12	Not used	Not used	ROW1_H	**28**	GND	GND	GND
13	Not used	Not used	ROW2_L	**29**	BIT54	BIT55	GND
14	Not used	Not used	ROW2_H	**30**	GND	GND	GND
15	Not used	Not used	ROW3_L	**31**	I/O	PCTL	PFLG
16	Not used	Not used	ROW3_H	**32**	GND	GND	GND

N2266A 40-Channel MUX Module

The Agilent N2266A is a configurable multiplexer (MUX) module. It contains 40 2-wire non-latching relays for switching and two non-latching tree relays for configuration applications.

The N2266A can be configured as:

- an 80-channel 1-wire multiplexer,
- a 40-channel 2-wire multiplexer (default),
- two independent 20-channel 2-wire multiplexer,
- or a 20-channel 4-wire multiplexer.

These modes can be selected from the front-panel or with a SCPI command (see page 83).

An instrument power-on or reset will set the N2266A to its default configuration as a 40-channel 2-wire MUX module. When instrument power is removed, all relays will open on the multiplexer.

The N2266A can be operated in either SCPI mode or 3488A mode, but configuration is only possible in the SCPI mode. In 3488A mode, the N2266A can only be used as a 40-channel 2-wire MUX module.

A parallel switching feature makes the N2266A well suited for high speed switching. The 40 2-wire relays on the N2266A can be separated into four groups and up to 10 relays in the same group can be closed simultaneously (parallel switching). The groups are: group 1 (channel 00 through channel 09), group 2 (channel 10 through channel 19), group 3 (channel 20 through channel 29) and group 4 (channel 30 through channel 39). Additional information about parallel switching is given on page 84.

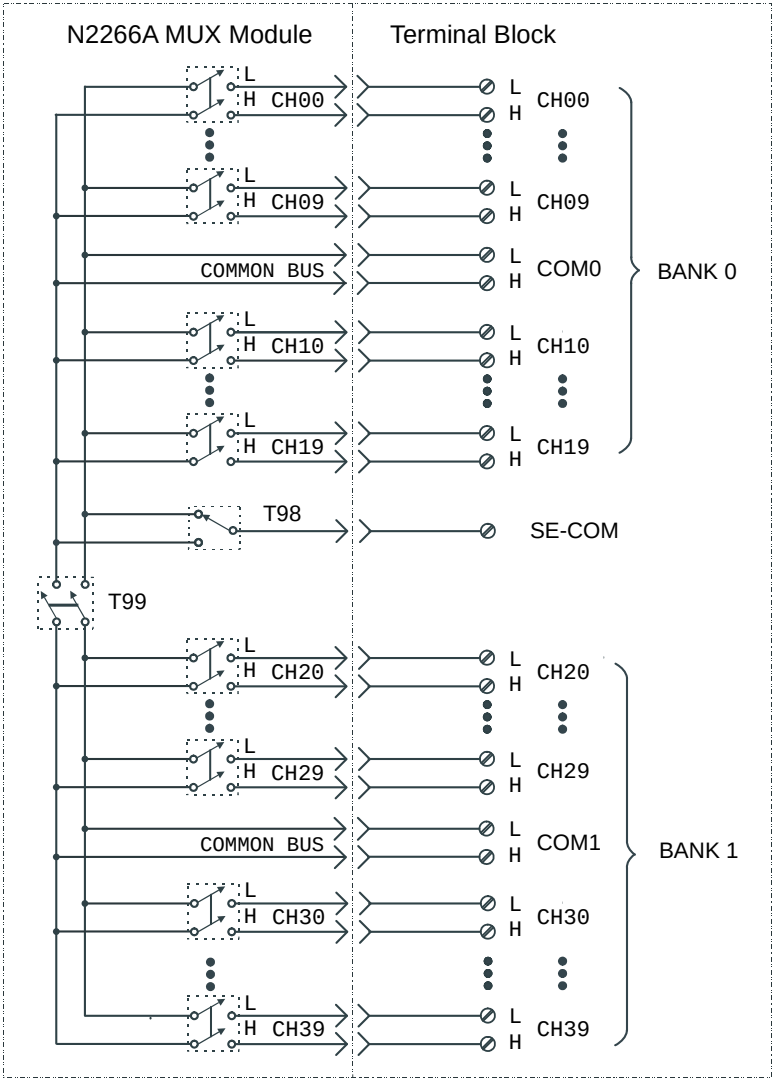
Specifications for the N2266A are given on page 315.

Caution

In order to stay within the 20W power limit set for convection cooling, no more than three (3) N2266A 40-Channel MUX Modules should be installed in an Agilent 3499A mainframe; the remaining two slots must remain empty. Other module combinations are acceptable; for example, two N2266A MUX modules plus any combination of other Agilent modules is permissible. This limitation does not apply to the 3499B or 3499C mainframes.

N2266A Simplified Schematic

The 40 2-wire channel relays (CH00-CH39) are divided into two banks: BANK 0 and BANK 1. Each bank consists of 20 2-wire switching channels and a common bus (COM0 & COM1). There is also a single-ended common terminal (SE-COM) used when the multiplexer is configured to 80-channel 1-wire mode. The two tree relays, T98 and T99, are used to configure the N2260A.



1-Wire Mode In this mode, either the High (H) or Low (L) terminal of a channel is switched to the single-ended (SE-COM) terminal. The Low terminals form the first 40 1-wire channels (00-39), and the High terminals form the second 40 1-wire channels (40-79). Only one channel can be closed at a time in the 1-wire mode.

Note Only one channel can be closed at a time in the 1-wire mode.

2-Wire Mode This is the default mode of the N2266A and provides 40 2-wire channels. In this mode, the Hi and Lo terminals of a channel are switched to Hi and Lo common terminals (COM0 and COM1). The channels are numbered 00 through 39.

Dual 2-Wire Mode In this mode, the N2266A is separated into two independent banks (BANK 0 & BANK 1). Each bank consists of 20 2-wire channels and a corresponding common bus, COM0 and COM1. The channels in BANK 0 are numbered 00 through 19, and the channels in BANK 1 are numbered 20 through 39.

Note You must modify the PC board to use this mode of operation. The modification is described in the next section.

4-Wire Mode In this mode, the two banks (BANK 0 & BANK 1) are paired to form a 20-channel 4-wire multiplexer. The first channels of each bank (CH00 & CH20) form Channel 00, the second channels of the each bank (CH01 & CH21) form Channel 01, and so on.

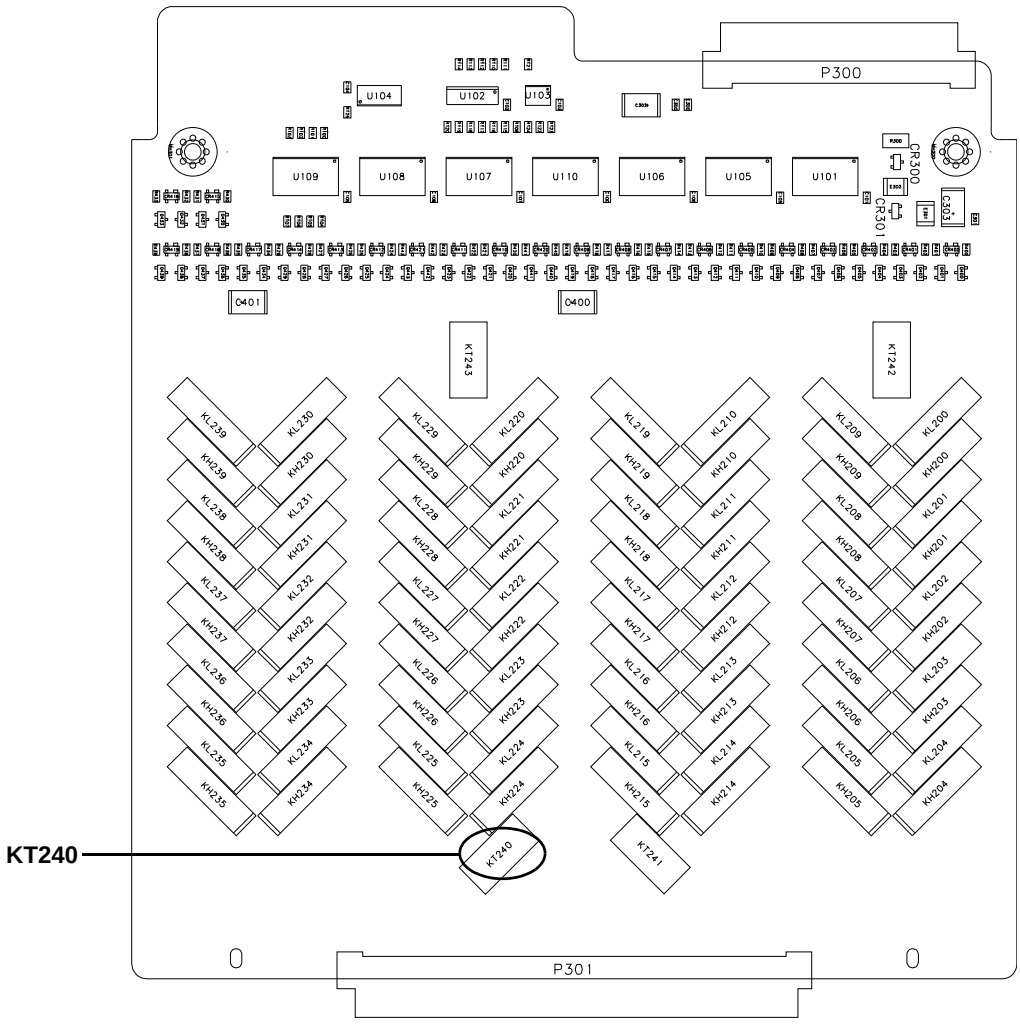
Note An instrument power-on or reset will set the N2266A to its default configuration as a 40-channel 2-wire MUX module. When powered off, all channels are opened.

Dual 2-Wire Mode - PC Board Modification

To operate the module in the Dual 2-wire mode, you must make modifications to the module's printed circuit board. Specifically, you must unsolder and remove relay T99. On the PC board, T99 has a reference designator of KT240. The location of KT240 is shown below.

Caution

You must use proper anti-static procedures, de-soldering techniques, and equipment to prevent damage to the PC board.

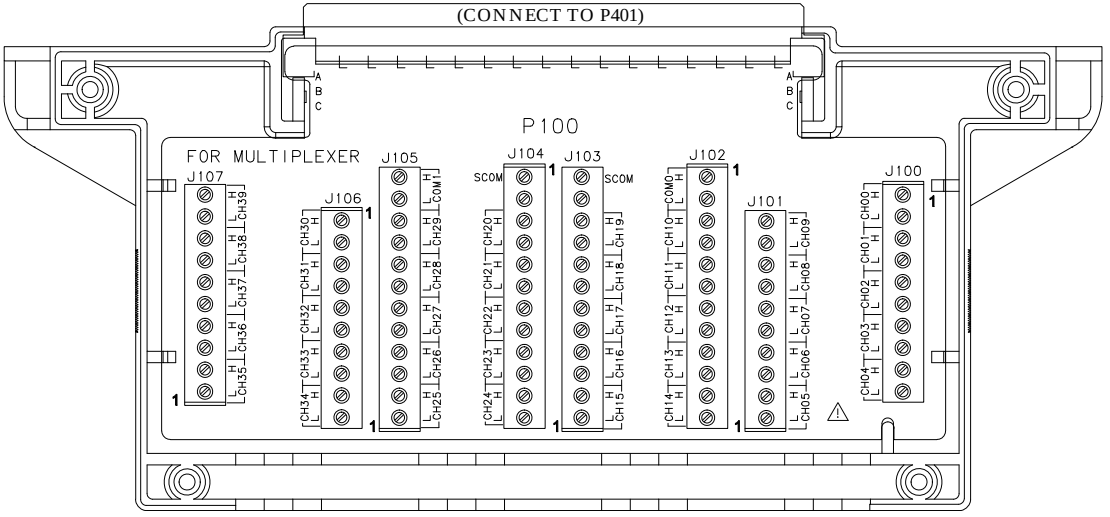


N2266A Wiring Information

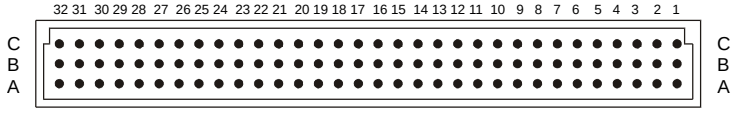
There are four methods available to connect to the N2266A:

- A screw terminal block, the N2296A (described on page 277).
- A direct wiring (insulation displacement) connector, the N2296A (described on page 278).
- A DIN96 to twin D50 Cable, the N2297A (described on page 279).
- A DIN96 to four D25 Cable, the N2299A (described on page 281).

The screw terminal block (N2290A) is shown below. To use the other connection options, you will need to use the pinout information on page 205.



N2266A Pinout P401 is a 96-pin male DIN connector mounted on the N2266A. The connector and pin assignments are shown below.



View from the Pin Side of the Connector

Pin #	A	B	C	Pin #	A	B	C
1	CH0_L	CH1_L	CH2_L	**17**	CH20_L	CH21_L	CH22_L
2	CH0_H	CH1_H	CH2_H	**18**	CH20_H	CH21_H	CH22_H
3	CH3_L	CH4_L	CH5_L	**19**	CH23_L	CH24_L	CH25_L
4	CH3_H	CH4_H	CH5_H	**20**	CH23_H	CH24_H	CH25_H
5	CH6_L	CH7_L	CH8_L	**21**	CH26_L	CH27_L	CH28_L
6	CH6_H	CH7_H	CH8_H	**22**	CH26_H	CH27_H	CH28_H
7	CH9_L	Not used	COM0_L	**23**	CH29_L	Not used	COM1_L
8	CH9_H	Not used	COM0_H	**24**	CH29_H	Not used	COM1_H
9	CH10_L	CH11_L	CH12_L	**25**	CH30_L	CH31_L	CH32_L
10	CH10_H	CH11_H	CH12_H	**26**	CH30_H	CH31_H	CH32_H
11	CH13_L	CH14_L	CH15_L	**27**	CH33_L	CH34_L	CH35_L
12	CH13_H	CH14_H	CH15_H	**28**	CH33_H	CH34_H	CH35_H
13	CH16_L	CH17_L	CH18_L	**29**	CH36_L	CH37_L	CH38_L
14	CH16_H	CH17_H	CH18_H	**30**	CH36_H	CH37_H	CH38_H
15	CH19_L	Not used	SE-COM	**31**	CH39_L	Not used	Not used
16	CH19_H	Not used	SE-COM	**32**	CH39_H	Not used	Not used

N2267A 8-Channel High Current GP Module

The Agilent N2267A is an 8-Channel High Current GP module typically used in mobile phone battery test applications. It can switch up to 8 A at 250 Vac or 5 A at 30 Vdc, with decreasing current to 1 A at 125 Vdc.

The module includes temperature control and protection circuitry, designed to prevent the module temperature from rising too high. The N2267A can potentially be switching up to 64 A (8 channels at 8 A). The temperature control circuitry prevents dangerous overheating.

The 8 channels of the N2267A are independent, more than one channel can be closed or opened at the same time.

Caution Exceeding the maximum switching current of 8 Ampere on any channel will damage the N2267A module and possibly the system.

Specifications for the N2267A are given on page 317.

Temperature Control

The temperature control circuitry includes two sensor ICs and a cooling fan. When the temperature of the N2267A reaches 45° C (113° F), the cooling fan on the module turns on. If the temperature drops below 40° C (104° F), the fan turns off.

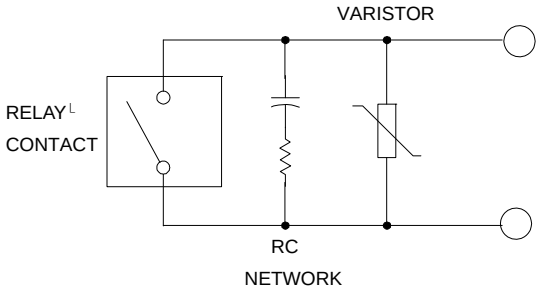
Over-temperature Protection

If the module temperature rises to 75° C (167° F), all channels on the module are opened and a TTL-level warning output (connected via SMB) on the rear panel will change from high to low. This output can be used to drive an external LED or buzzer. The warning output will reset (change from low to high) when the module temperature drops below 59° C (138° F).

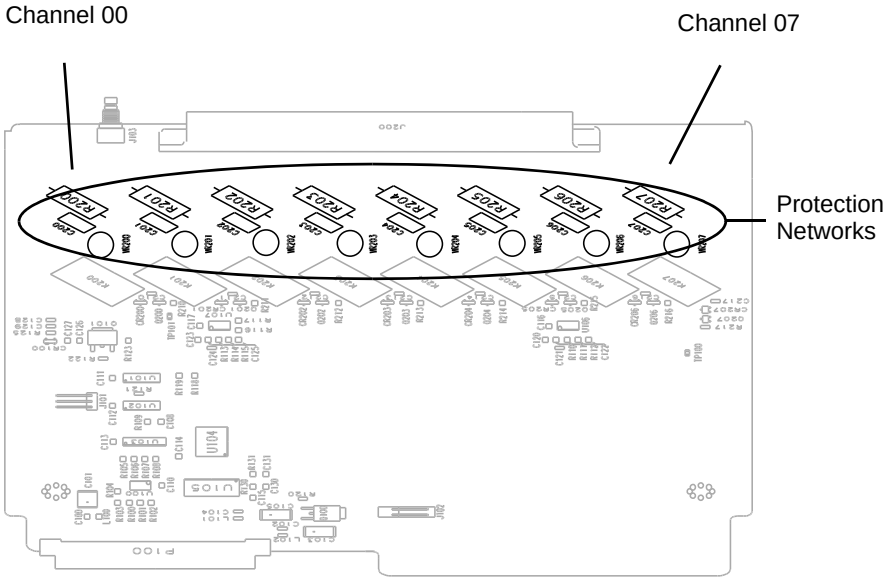
The over-temperature protection is controlled by hardware logic on the module. Therefore, if the over-temperature protection has opened all the channels on the module, the mainframe front-panel and system memory will still indicate the original state of the channels. To regain control of the channels, you must cycle the power to the module (reset and channel commands will not work). Note that cycling power to regain control will only work if the module temperature has dropped below 59° C (138° F) otherwise the protection circuitry will be activated again.

Protection Network

The module circuit board contains provisions to allow you to mount relay protection circuits. Inductive loads may exhibit large transient currents that can damage the relay contacts. The type of protection and component values are determined by the loads being switched. More detailed information about protection circuits is given on page 272.



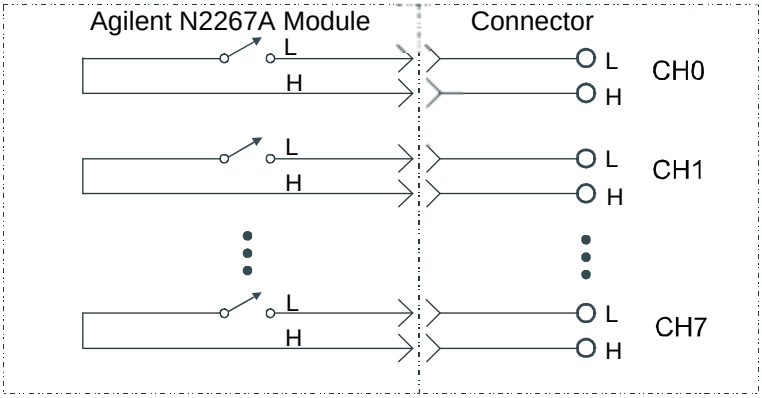
The N2267A circuit board has a provision to allow you to install protection networks in the relay paths. The figure below shows the locations on the main circuit board.



7

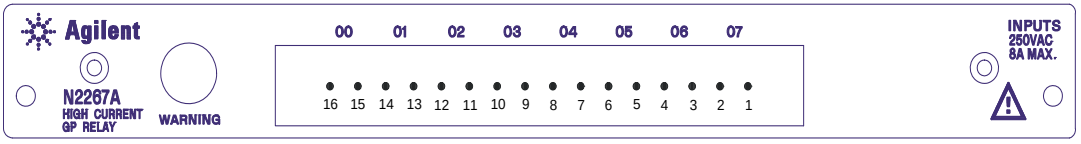
N2267A Simplified Schematic

A simplified schematic is shown below. The N2267A consists of eight independent high current channels, each containing a Single Pole-Single Throw (SPST) Normally Open (Form A) relay.



N2267A Wiring Information

The N2267A rear panel has two connectors: an SMB for the over-temperature warning signal, and a 16-pin male connector for connections to the relay contacts.



The 16-pin connector on the rear-panel is an AMP Metrimate In-Line Connector: Right Angle Header 207544-1.

An Agilent N2327A terminal block can be used to make the connections to the N2267A. Included in the N2327A are an AMP Metrimate In-Line Connector: Plug, 207542-1 and an AMP Contact Type III Socket AWG18-14, 66360-2. Refer to page 282 for more information about the N2327A.

WARNING

Voltages greater than 30 Vrms, 42 Vpk or 60 Vdc present an electric shock hazard. Disconnect source voltages before removing or connecting the source-to-module I/O connector or wiring the connector. All field wiring must be rated for the highest voltage applied to any single channel.

N2267A Pinout J200 is a 16-pin male connector mounted on the rear panel of the N2267A. The pinout assignments are shown below.

Pin#	Signal Name	Pin#	Signal Name
1	CH7_H	**9**	CH3_H
2	CH7_L	**10**	CH3_L
3	CH6_H	**11**	CH2_H
4	CH6_L	**12**	CH2_L
5	CH5_H	**13**	CH1_H
6	CH5_L	**14**	CH1_L
7	CH4_H	**15**	CH0_H
8	CH4_L	**16**	CH0_L

Over-temperature Pinout J103 is an SMB connector mounted on the rear panel of the N2267A. The center conductor is a TTL signal. The shield is connected to the module ground.

N2268A 50Ω 3.0 GHz Dual 1-to-4 MUX Module

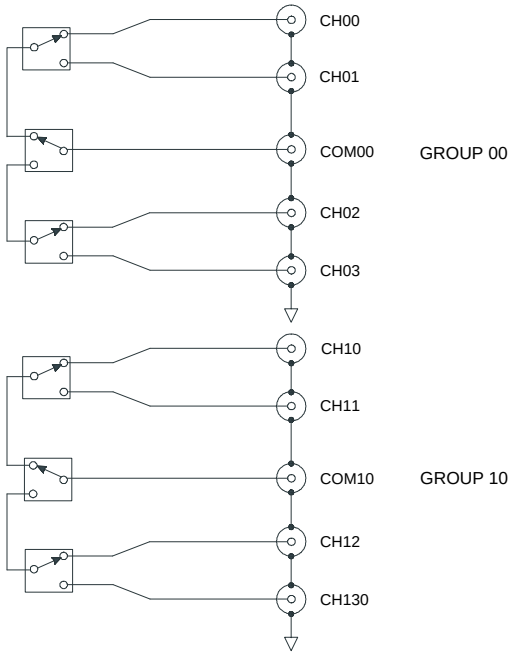
The Agilent N2268A consists of two, independent, 1-to-4 MUX switches (GROUP 00 and GROUP 10) that provide bidirectional switching. The latching relays in this module are configured in a “tree” structure to provide isolation and low VSWR (voltage standing wave ratio). Each channel in this module can switch up to 30 Vdc or peak ac at frequencies from dc to 3.0 GHz.

Specifications for the N2268A are given on page 319.

N2268A Simplified Schematic

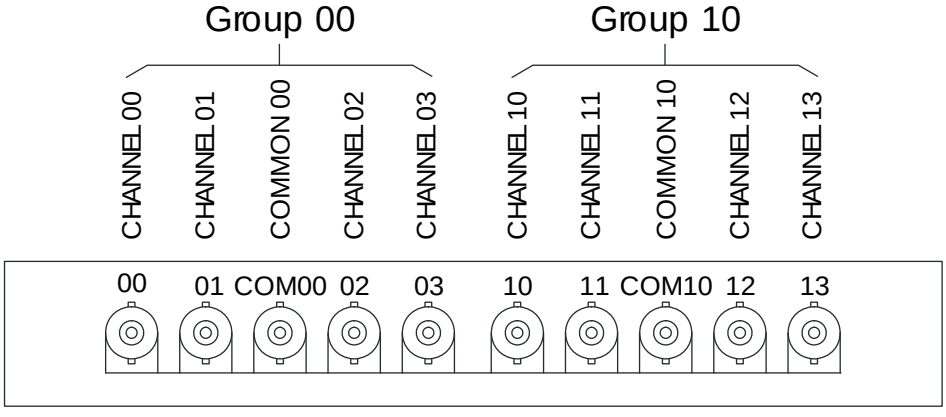
A simplified schematic is shown on the next page. The N2268A contains two 1-to-4 MUXs, designated as GROUP 00 and GROUP 10. The two groups are isolated from each other. Each 1-to-4 multiplexer consists of three form-C relays. A tree relay is connected to the common channel. The two channel relays allow selection of one of the four channel in each group. Channels in each group are break-before-make and are numbered as 00 through 03 for GROUP 00 and 10 through 13 for GROUP 10.

One channel in each group is connected to the common terminals. By default, COM00 is connected to CH00 and COM10 is connected to CH10.



N2268A Wiring Information

The rear panel of the N2268A is shown below. Use male SMA connectors to connect external signals to the N2268A module.



N2270A 10-Channel High Voltage MUX Module

The Agilent N2270A is a 10-Channel 2-wire High Voltage multiplexer typically used in the semiconductor test field. The Maximum Switching Voltage is 1000 V peak, and the Maximum Switching Power is 10 W.

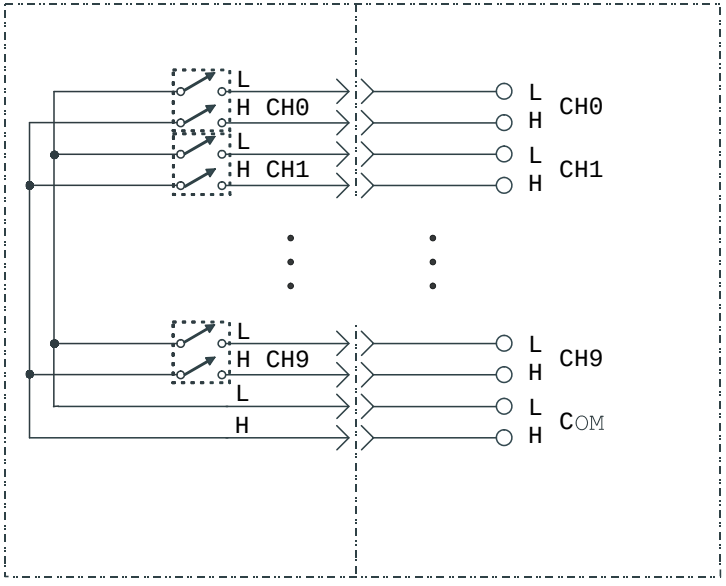
The module has a metal shell to minimize interference while switching high voltage.

Specifications for the N2270A are given on page 321.

WARNING *Hazardous voltages may exist on the wiring and connectors. DO NOT remove or install the module or the module connector until all external voltages have been removed.*

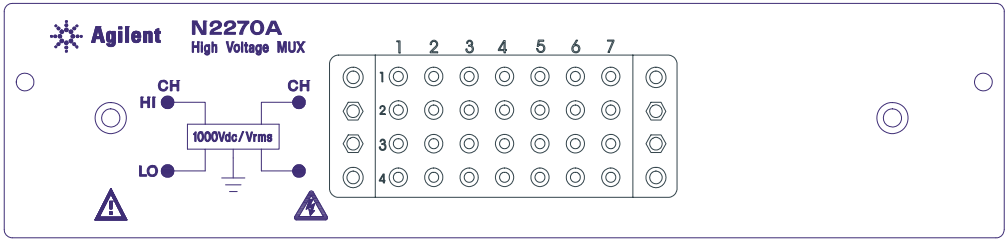
N2270A Simplified Schematic

A simplified schematic is shown below. The N2270A consists of 10 2-wire channels and a common bus. The 10 channels of the N2270A are numbered from 00 through 09 (CH0 through CH9).



N2270A Wiring Information

The 28-pin connector on the rear panel is an AMP 1800V Plug Connector 205689-2.



An Agilent N2320A terminal block can be used to wire external high voltage signals to the N2270A. Included in the N2320A are an AMP 1800V Receptacle Connector, 205690-2 and an AMP AWG24-20 Socket 66399-4. The connector has a metal strain relief and you must make sure to use additional insulation around the wires to prevent the wire insulation being cut, broken or otherwise damaged at the strain relief clamp. Refer to page 283 for more information about the N2320A.

WARNING

Voltages greater than 30 Vrms, 42 Vpk or 60 Vdc present an electric shock hazard. Disconnect source voltages before removing or connecting the source-to-module I/O connector or wiring the connector. All field wiring must be rated for the highest voltage applied to any channel.

N2270A Pinout The pinout assignments are shown below.

	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
Row1	CH2_H	CH3_H	CH4_H	Not Used	CH5_H	CH6_H	CH7_H
Row2	CH2_L	CH3_L	CH4_L	Not Used	CH5_L	CH6_L	CH7_L
Row3	CH0_H	CH1_H	Not Used	COM_H	Not Used	CH8_H	CH9_H
Row4	CH0_L	CH1_L	Not Used	COM_L	Not Used	CH8_L	CH9_L

N2272A 1 GHz RF 1-to-9 MUX Module

The Agilent N2272A is a 1 GHz RF 1-to-9 Multiplexer well suited for use in RF test and measurement applications. Seven channels are standard branch channels. One channel, CH08, has smaller insertion loss and lower VSWR and can be used either as standard branch channel or an auxiliary channel.

Using the auxiliary channel, CH08, multiple N2272A modules can be cascaded to form larger RF multiplexers while minimizing performance degradation. For example, by connecting CH08 to the COM of a second N2272A, a 17:1 multiplexer can be configured. Adding another N2272A to channel 8 of the second N2272A allows a 25:1 multiplexer to be configured, and so on.

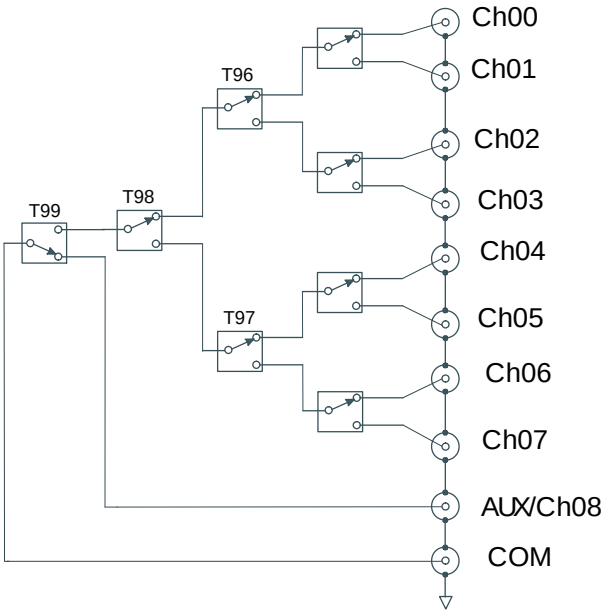
Only one channel can be closed at a time. The Agilent N2272A does not support the OPEN command (one channel must always be closed). Closing a channel opens any other closed channel.

Note The Agilent N2272A can only be used with the SCPI Mode of 3499 Firmware Revision 3.0 or later. See page 59 for details about the firmware revisions.

Specifications for the N2272A are given on page 323.

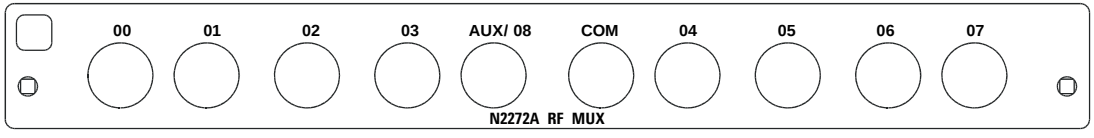
N2272A Simplified Schematic

A simplified schematic is shown below. The N2272A consists of series of latching RF relays arranged in a tree structure. One common channel (COM) and nine branch channels (numbered as CH00 through CH08) are included in the N2272A. CH08 is also called an auxiliary channel and can be used to expand channel count by connecting to another N2272A. CH08 passes through only one relay and has a very short PC board trace to provide smaller insertion loss and lower VSWR than the other channels. Only one channel can be closed at a time. In addition to the channel relays, you can also query the relay cycle count of the tree relays (T96, T97, T98, and T99).



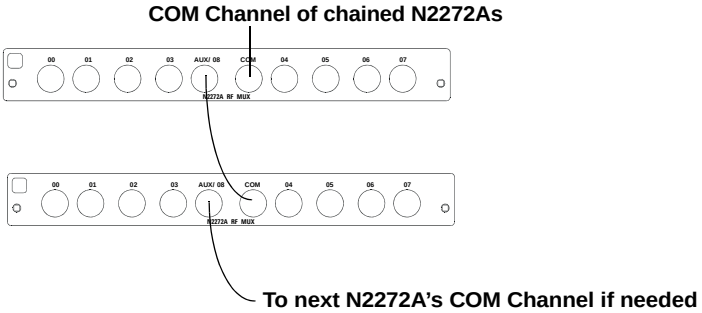
N2272A Wiring Information

The rear panel of the N2272A contains 10 female BNC connectors.

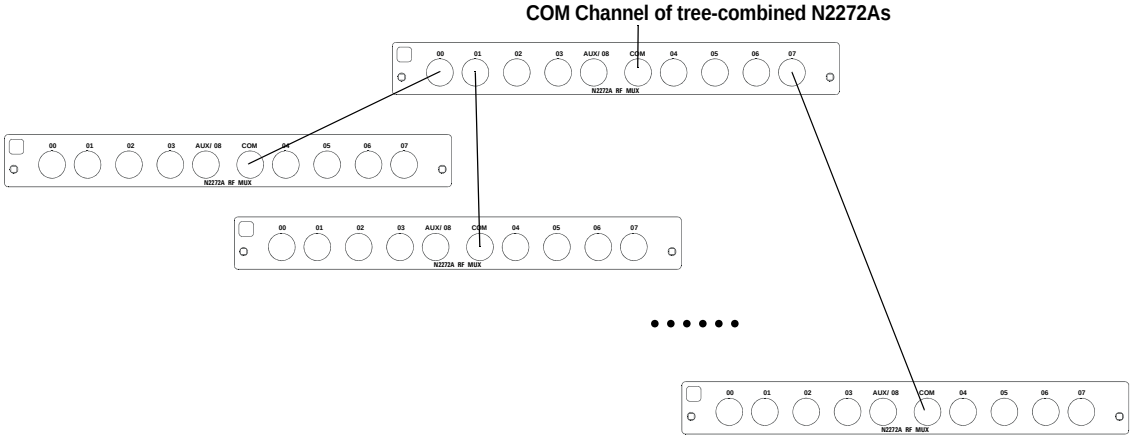


Connecting Multiple N2272A's

The figure below illustrates how to connect two or more N2272A's together to form larger channel count multiplexers. Additional N2272A's are added by connecting each COM to the low insertion loss/low VSWR auxiliary channel on the first N2272A.The example below, shows a 1-to-16 multiplexer. Channel 00 through 07 are on the first N2272A, and channel 08 through 15 are on the second N2272A. Switch the first N2272A COM to AUX/08 to access the second bank of multiplexer channels. Additional multiplexers can be added as necessary.


COM Channel of chained N2272As
00 01 02 03 AUX/ 08 COM 04 05 06 07
N2272A RF MUX
00 01 02 03 AUX/ 08 COM 04 05 06 07
N2272A RF MUX
To next N2272A's COM Channel if needed

You can also connect multiple N2272A's in a tree structure to implement high channel count multiplexers, however, this configuration will cause signal delays.



N2276A Dual 1-to-6(4) Microwave MUX/ Attenuator Module

The Agilent 2276A contains microwave switch and attenuator driver circuits. The microwave switches or attenuators can be mounted to the rear panel of the module or connected with an auxiliary cable for convenience. Several microwave switches and attenuators are available for use with the module.

The N2276A is preconfigured in one of two options:

Option	Configuration	Switches Used
204	Dual 1-to-4 up to 20 GHz	87104B
206 (default)	Dual 1-to-6 up to 20 GHz	87106B

The N2276A is a three slot module and cannot be used in the 3499B two-slot mainframe.

Due to the drive circuitry, each N2276A causes about 0.5 second's delay during power up. Your 3499A/C may seem to turn on slower after you add N2276A modules.

An 8-bit DIP switch on the module sets the configuration for the switches and attenuators. Four connectors are located on the module; two 16-pin connectors (labeled as switch0 & switch1) for connecting switches and two 10-pin connectors (labeled as attenuator0 & attenuator1) for connecting attenuators.

Note The Agilent N2276A can only be used with the SCPI Mode of 3499A/C Firmware Revision 3.0 or later. See page 59 for details about the firmware revisions.

Caution The driving circuitry of the module is capacitive. Turn off power before installing or removing the module, switches, or attenuators.

Specifications for the N2276A are given on page 325.

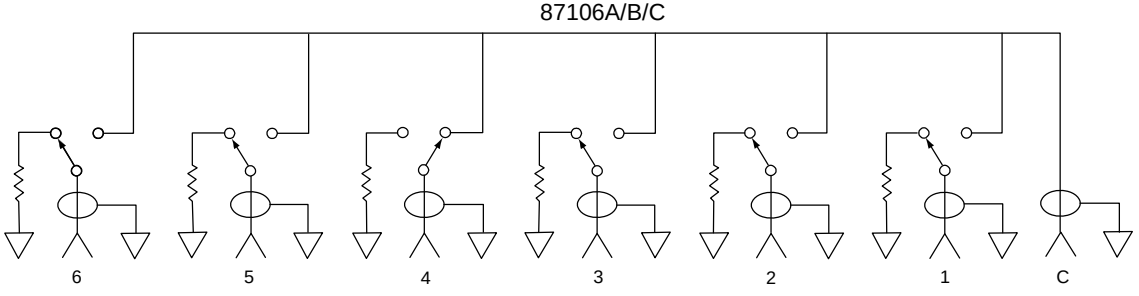
Up to two attenuators can be added to the N2272A using provided ribbon cables. The following attenuators (user provided) are available from Agilent:

External Attenuators (up to two may be used)	
0 to 11 dB in 1 dB steps	
Agilent 84904K	up to 26.5 GHz
Agilent 84904L	up to 40 GHz
0 to 90 dB in 10 dB steps	
Agilent 84906K	up to 26.5 GHz
Agilent 84906L	up to 40 GHz
0 to 70 dB in 10 dB steps	
Agilent 84907K	up to 26.5 GHz
Agilent 84907L	up to 40 GHz

N2276A Simplified Schematic

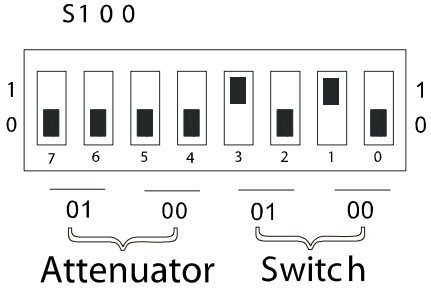
The simplified schematic below shows the Agilent 87106B 1-to-6 microwave switch (option 206) as used in the Agilent N2276A. Please refer to the switch or attenuator data sheets for information specific to each switch and attenuator.

Only one channel in a switch may be closed at a time. Closing a channel will open any previously closed channel.



Configuration

An 8-bit DIP switch (labeled S100) on the N2276A is used to configure the switches and optional attenuators. The following table shows specific configurations. If the 8-bit DIP switch's configuration does not match the switches or attenuators installed, errors or unexpected results will occur.

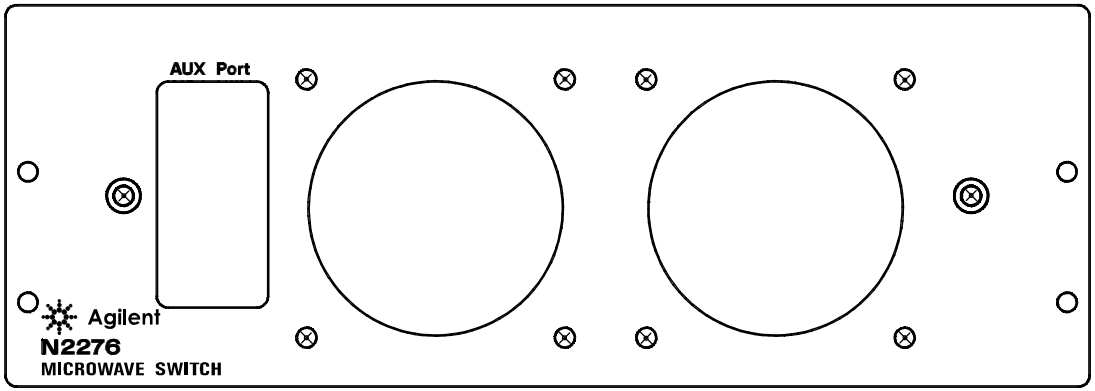


Bit Setting	Attenuator 1	Attenuator 0	Switch 1	Switch 0
	Bit 7- 6	**Bit 5- 4**	**Bit 3- 2**	**Bit 1- 0**
00	None	None	None	None
01	84904K/L	84904K/L	87104A/B/C	87104A/B/C
10	84906K/L	84906K/L	87106A/B/C	87106A/B/C
11	84907K/L	84907K/L	Reserved	Reserved

N2276A Wiring Information

All the microwave switches for the N2276A have SMA female connectors. For the attenuators, each standard 84904/6/7L model offers two female 2.4 mm connectors and each 84904/6/7L model with option 006 has two female 2.92 mm connectors (compatible with SMA connectors). When using 84904/6/7L series attenuators, be sure to order them with option 006 (SMA compatible) for wiring convenience.

The default ribbon cable for connecting attenuators to N2276A/B is 1.5 m in length. A 1.5 m length ribbon cable for connecting microwave switches to the switch connectors on the N2276A is available as Agilent part number N2276-61003. This cable permits the microwave switches to be placed in a convenient location.



N2276B Microwave MUX/Attenuator Module

The Agilent N2276B contains microwave switch and attenuator driver circuits. The microwave switches or attenuators can be mounted to the rear panel of the module or connected with an auxiliary cable for convenience.

The N2276B is shipped without any switches, allowing for custom configuration. Several microwave switches and attenuators are available for use with the module.

The N2276B is a three slot module and cannot be used in the 3499B two-slot mainframe.

Due to the drive circuitry, each N2276B causes about 0.5 second's delay during power up. Your 3499A/C may seem to turn on slower after you add N2276B modules.

An 8-bit DIP switch on the module sets the configuration for the switches and attenuators. Four connectors are located on the module; two 16-pin connectors (labeled as switch0 & switch1) for connecting switches and two 10-pin connectors (labeled as attenuator0 & attenuator1) for connecting attenuators.

Note The Agilent N2276B can only be used with the SCPI Mode of 3499A/B/C Firmware Revision 3.0 or later. See page 59 for details about the firmware revisions.

Caution The driving circuitry of the module is capacitive. Turn off power before installing or removing the module, switches, or attenuators.

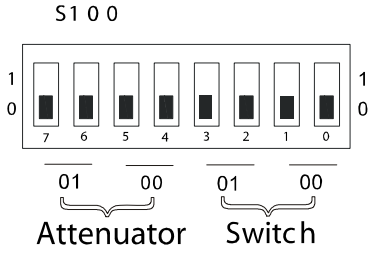
Specifications for the N2276B are given on page 325.

The following switches and attenuators are available from Agilent:

Switches (1x4) SP4T	
Agilent 87104A	dc to 4 GHz
Agilent 87104B	dc to 20 GHz
Agilent 87104C	dc to 26.5 GHz
Switches (1x6) SP6T	
Agilent 87106A	dc to 4 GHz
Agilent 87106B	dc to 20 GHz
Agilent 87106C	dc to 26.5 GHz
External Attenuators (up to two may be used)	
0 to 11 dB in 1 dB steps	
Agilent 84904K	up to 26.5 GHz
Agilent 84904L	up to 40 GHz
0 to 90 dB in 10 dB steps	
Agilent 84906K	up to 26.5 GHz
Agilent 84906L	up to 40 GHz
0 to 70 dB in 10 dB steps	
Agilent 84907K	up to 26.5 GHz
Agilent 84907L	up to 40 GHz

Configuration

An 8-bit DIP switch (labeled S100) on the N2276B is used to configure optional switches and attenuators. The following table shows specific configurations. If the 8-bit DIP switch's configuration does not match the switches or attenuators installed, errors or unexpected results will occur.

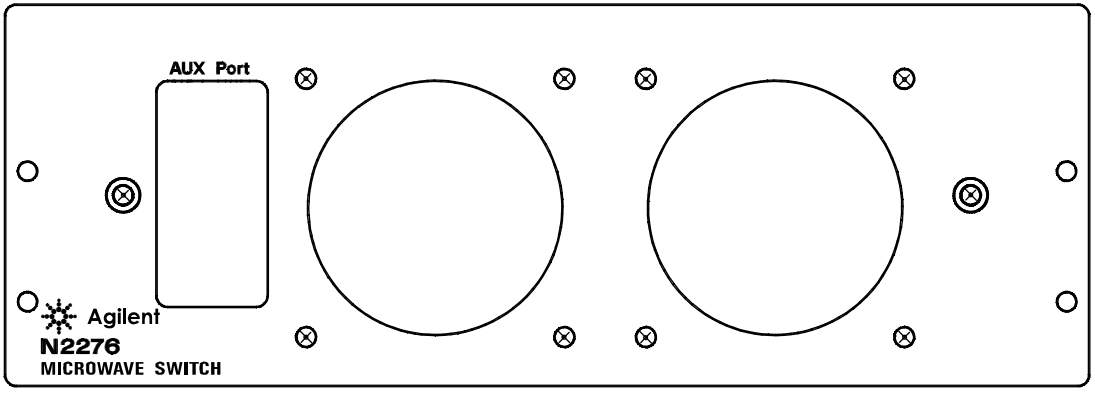


Bit Setting	Attenuator 1	Attenuator 0	Switch 1	Switch 0
	Bit 7- 6	**Bit 5- 4**	**Bit 3- 2**	**Bit 1- 0**
00	None	None	None	None
01	84904K/L	84904K/L	87104A/B/C	87104A/B/C
10	84906K/L	84906K/L	87106A/B/C	87106A/B/C
11	84907K/L	84907K/L	Reserved	Reserved

N2276B Wiring Information

All the microwave switches for the N2276B have SMA female connectors. For the attenuators, each standard 84904/6/7L model offers two female 2.4 mm connectors and each 84904/6/7L model with option 006 has two female 2.92 mm connectors (compatible with SMA connectors). When using 84904/6/7L series attenuators, be sure to order them with option 006 (SMA compatible) for wiring convenience.

The default ribbon cable for connecting attenuators to N2276B is 1.5 m in length. The default ribbon cable for connecting switches to N2276B is 1.5 m in length. A 1.5m length ribbon cable for connecting microwave switches to the switch connectors on the N2276B is available as Agilent part number N2276-61003. This cable permits the microwave switches to be placed in a convenient location.



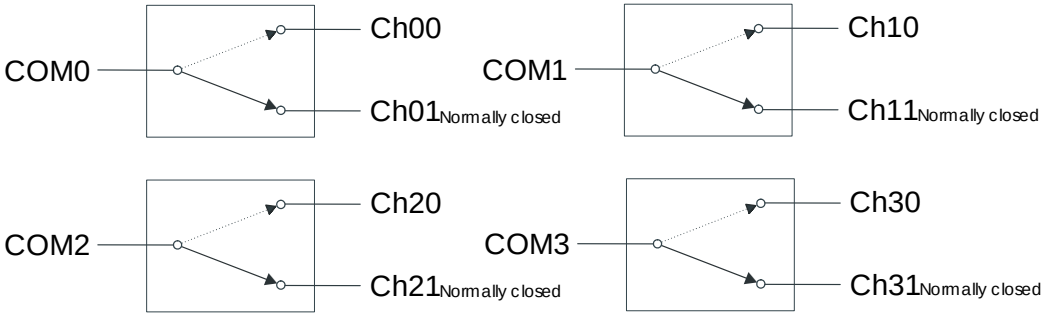
N2280A Quadruple 1-to-2 Optical Switch Module

The Agilent N2280A Module contains four 1-to-2 optical switches. All four optical switches are non-latching. For each switch, only one channel can be closed at a time. Closing a channel will open the other channel in the same switch. After power on or a reset, the common channel of each 1-to-2 optical switch is connected to the second channel by default.

Specifications for the N2280A are given on page 326.

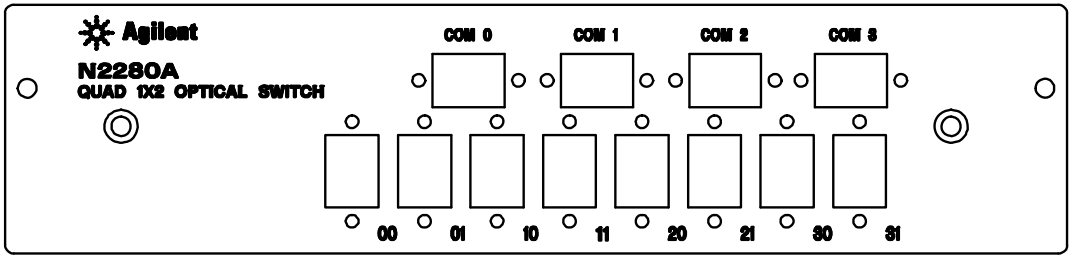
N2280A Simplified Schematic

A simplified schematic is shown below. The N2280A consists of four independent 1-to-2 optical switches. Each optical switch has one COM*x* and two branch channels named Ch*x*0 and Ch*x*1.



N2280A Wiring Information

Use SC/APC connectors to connect external optical signals to the N2280A module. The rear panel of the N2280A is shown below.



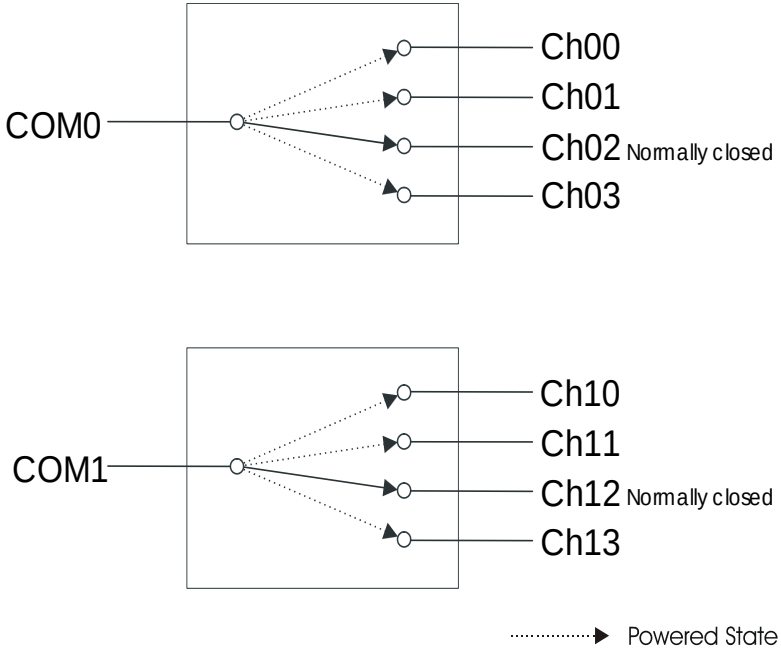
N2281A Dual 1-to-4 Optical Switch Module

The Agilent N2281A Module consists of two 1-to-4 optical switches. The two optical switches are non-latching. For each switch, only one channel can be closed at a time. Closing one channel will open the other channel in the same switch. After power on or a reset, the common channel of each 1-to-4 optical switch is connected to the third channel by default.

Specifications for the N2281A are given on page 327.

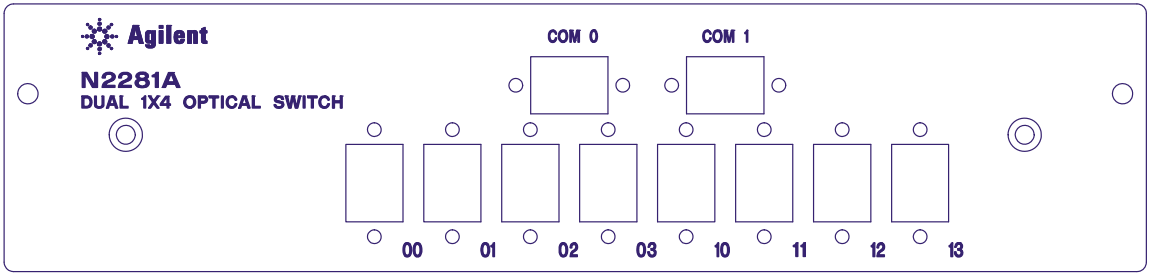
N2281A Simplified Schematic

A simplified schematic is shown below. The Agilent N2281A consists of two independent 1-to-4 optical switches. Channels are numbered as 00, 01, 02, 03 for COM0 and 10, 11, 12, 13 for COM1. The third channel of each 1-to-4 optical switch is connected to the common channel by default.



N2281A Wiring Information

Use SC/APC connectors to connect external optical signals to the N2281A module. The rear panel is shown below.



N2282A 1-to-8 Optical Switch Module

The Agilent N2282A Optical Switch contains a latching 1-to-8 optical switch. Only one channel at a time may be closed. The N2282A does not support the OPEN command. Closing a channel will open any previously closed channels. A special, virtual channel is included that allows all channels in the switch to be opened.

Channels are numbered as CH00 through CH08. CH00 through CH07 are standard channels. CH08 is a special channel used when programming to open all other channels (CH00 through CH07). The latching characteristic of the optical switch makes it hold its most recently state after powered off.

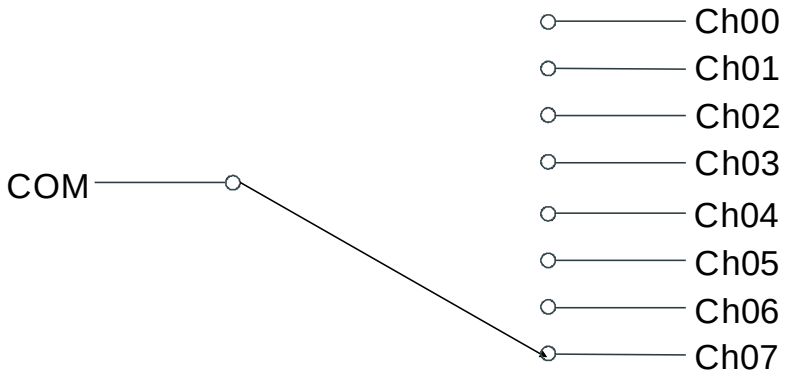
Specifications for the N2282A are given on page 328.

Note The Agilent N2282A can only be used with the SCPI Mode of 3499 Firmware Revision 3.0 or later. See page 59 for details about the firmware revisions.

N2282A Simplified Schematic

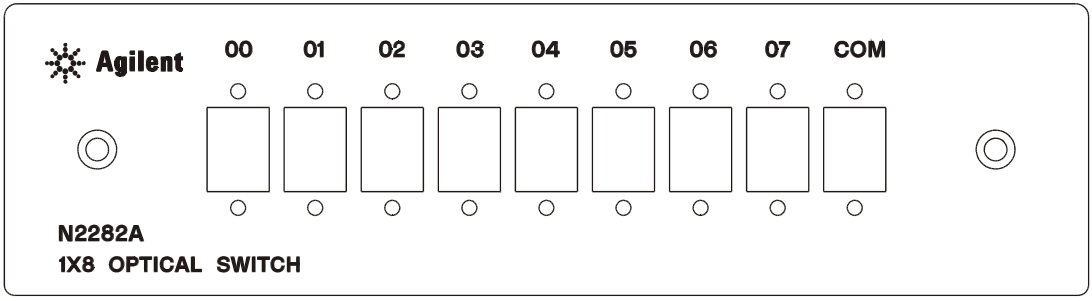
A simplified schematic is shown on the next page. The N2282A consists of one 1-to-8 optical switch whose channels are numbered as CH00 through CH07 and a special channel, CH08, with no external connection.

CH00 through CH07 are opened when a `ROUTe:CLOSe (@x08)` command is sent (where *x* is the slot number containing the N2282A).



N2282A Wiring Information

Use SC/APC connectors for wiring external optical signals to the N2282A module. The rear panel is shown below.



Note The Agilent N2282A module extends an additional 8.5 cm beyond the rear panel of the 3499A/B/C mainframe.

44470A 10-Channel MUX Module

The Agilent 44470A Relay Multiplexer (MUX) provides 10 2-wire channels (latching relays) to switch both Hi (H) and Lo (L) input signal lines to a common bus. Relays on this module are rated at a maximum voltage of 250 volts with a maximum current of 2 amps dc or ac rms.

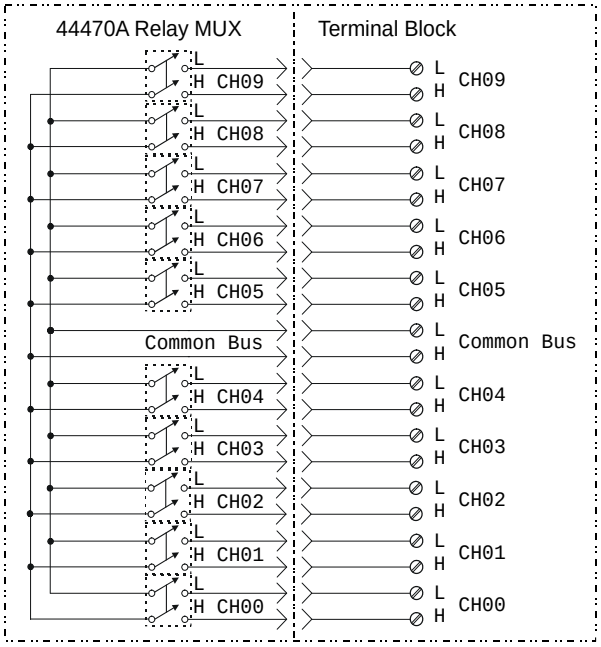
The module exhibits low thermal offset characteristics, making it ideal for precision low-level measurements. However, since no thermocouple compensation is included, temperature measurement errors may occur if you use this module to switch thermocouples.

The 44470A can be operated in either of two modes, single channel break-before-make (BBM), or multiple channels closed at the same time.

Specifications for the 44470A are given on page 329.

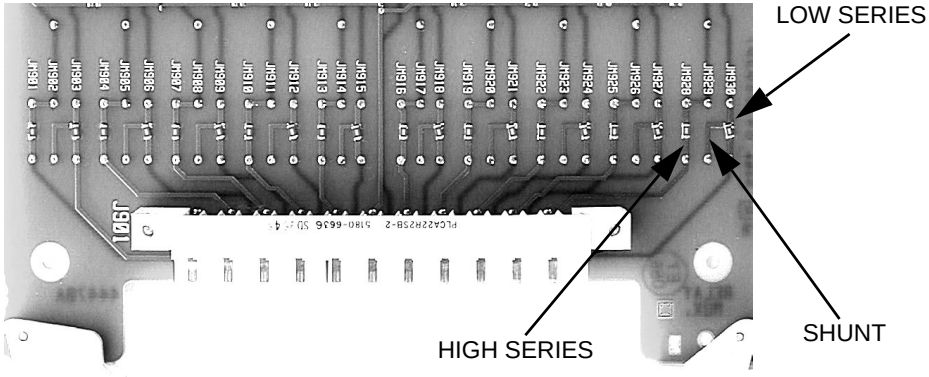
44470A Simplified Schematic

A simplified schematic of the 44470A is shown below. The 44470A consists of 10 2-wire relay channels that may be connected to a common bus. Channels on the 44470A are numbered as 00 through 09 (CH00 through CH09).

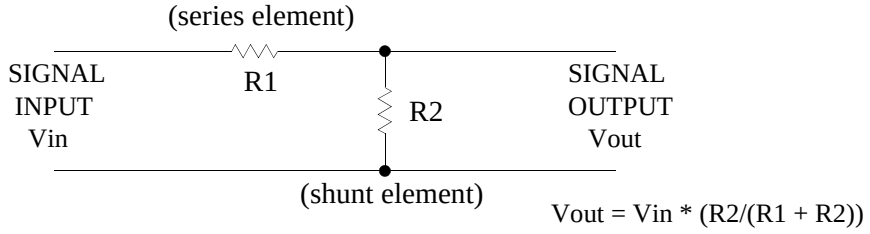


Custom Signal Conditioning

The 44470A circuit board has provision that allow you to install simple attenuators or filter networks. Three circuit pads in each relay path are provided that allow you to install components in the signal Hi path, Lo path, or as a shunt from Hi to Lo. The figure below shows the 44470A circuit board locations where components can be installed.



Creating attenuators An attenuator is composed of two resistors that act as a voltage divider. A typical attenuator circuit is also shown below.



To select the attenuator components, use the following equation:

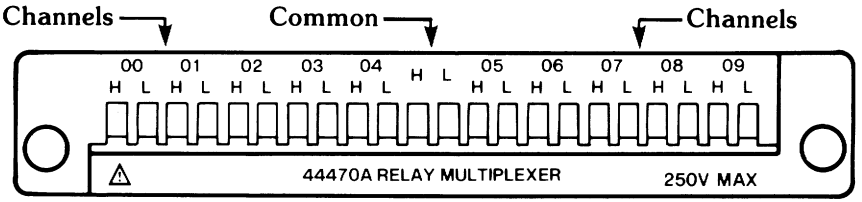
$$Vo = Vi \times R2/(R1 + R2)$$

One typical use for the shunt component is to convert the output of 4 to 20 mA transducers to a voltage that can be measured using a DMM. A 50 Ω, ±1%, 0.5 watt resistor can be installed in the R2 (shunt) location and the resultant voltage drop (transducer current through the resistor) measured. The 50 Ω resistor converts the 4 - 20 mA current to an 0.2 - 1 volt signal. No series element (R1) is needed.

44470A Wiring Information

Use the Agilent 44480A Terminal Block to make connections to the 44470A. One 44480A is supplied with the module.

The terminal block includes a screw terminal that connects external wiring to the 44470A. The screw terminal is shown below. Additional information about the terminal block is given on page 285.



44470D 20-Channel MUX Module

The Agilent 44470D Relay MUX Module provides 20 2-wire channels (latching relays) to switch both High (H) and Low (L) input signals to a common bus. The individual relays on this module are rated at a maximum voltage of 250 volts with a maximum current of 2 amps dc or ac rms.

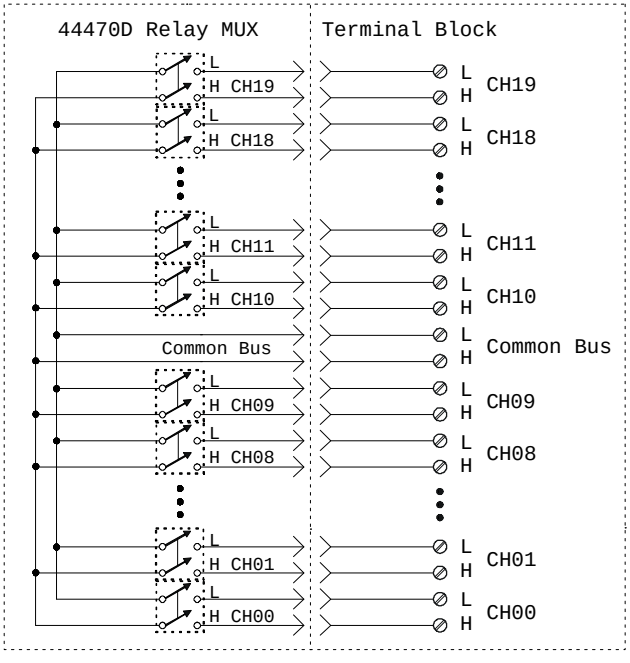
The module exhibits low thermal offset characteristics, making it ideal for precision low-level measurements. However, since no thermocouple compensation is included, temperature measurement errors may occur if you use this module to switch thermocouples.

The 44470D can be operated in one of two modes: single channel break-before-make (BBM) or multiple channels closed at the same time.

Specifications for the 44470D are given on page 331.

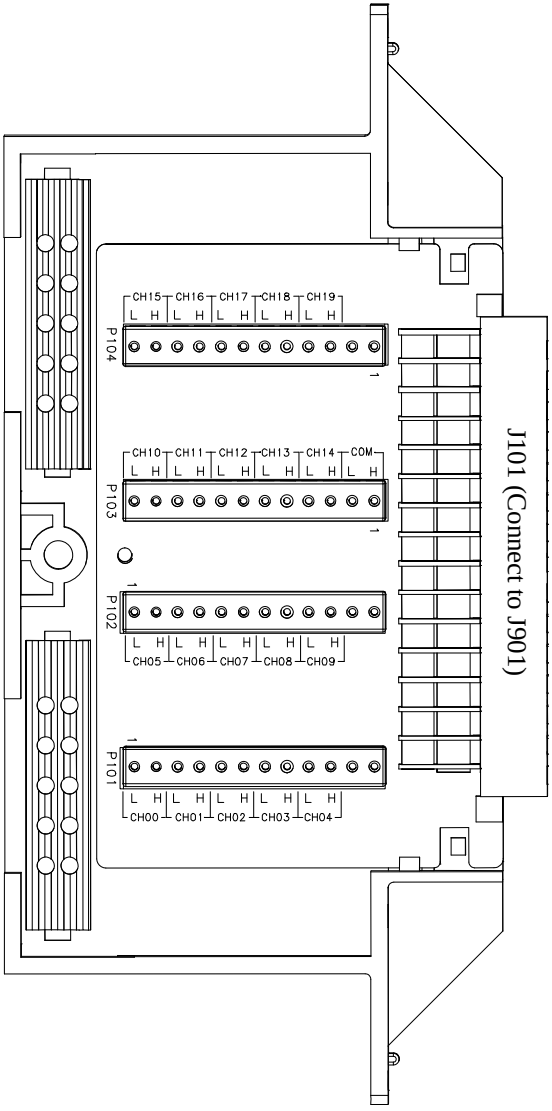
44470D Simplified Schematic

A simplified schematic is shown below. The 44470D consists of 20 2-wire relays connected to a common bus. Channels on the 44470D are numbered as 00 through 19 (CH00 through CH19).



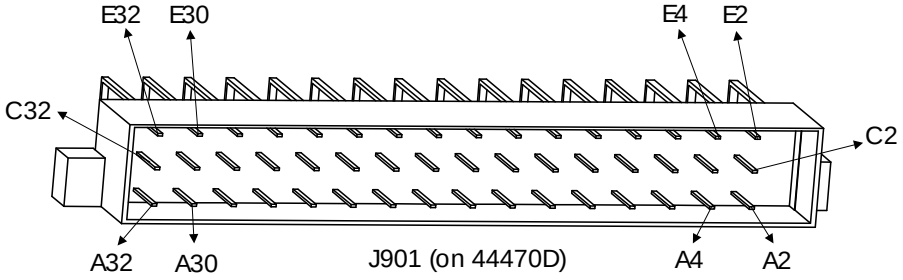
44470D Wiring Information

Use the Agilent 44480B Terminal Block to make connections to the 44470D. One 44480B is supplied with the module. The terminal block connectors are shown below. Additional information about the terminal block is given on page 287.


CH15 CH16 CH17 CH18 CH19
L H L H L H L H L H
P104
CH10 CH11 CH12 CH13 CH14 COM
L H L H L H L H L H L H
P103
P102
L H L H L H L H L H
CH05 CH06 CH07 CH08 CH09
P101
L H L H L H L H L H
CH00 CH01 CH02 CH03 CH04
J101 (Connect to J901)

44470D J901 Pinout

J901 is a 3-row, 48-pin male connector mounted on the 44470D. The pin assignments in this connector are shown below.



J901 A2	CH00 L	A8	CH05 L	A18	CH10 L	A24	CH15 L
C2	CH00 H	C8	CH05 H	C18	CH10 H	C24	CH15 H
E2	CH01 L	A10	CH06 L	E18	CH11 L	A26	CH16 L
E4	CH01 H	C10	CH06 H	E20	CH11 H	C26	CH16 H
A4	CH02 L	E10	CH07 L	A20	CH12 L	E26	CH17 L
C4	CH02 H	E12	CH07 H	C20	CH12 H	E28	CH17 H
A6	CH03 L	A12	CH08 L	A22	CH13 L	A28	CH18 L
C6	CH03 H	C12	CH08 H	C22	CH13 H	C28	CH18 H
E6	CH04 L	A14	CH09 L	E22	CH14 L	A30	CH19 L
E8	CH04 H	C14	CH09 H	E24	CH14 H	C30	CH19 H
E14	NC	E30	NC	A16	L COM	C32	NC
C16	NC	A32	NC	E16	H COM	E32	NC

A32, C16, C32, E14, E30, E32 NOT CONNECTED (NC)

44471A 10-Channel GP Relay Module

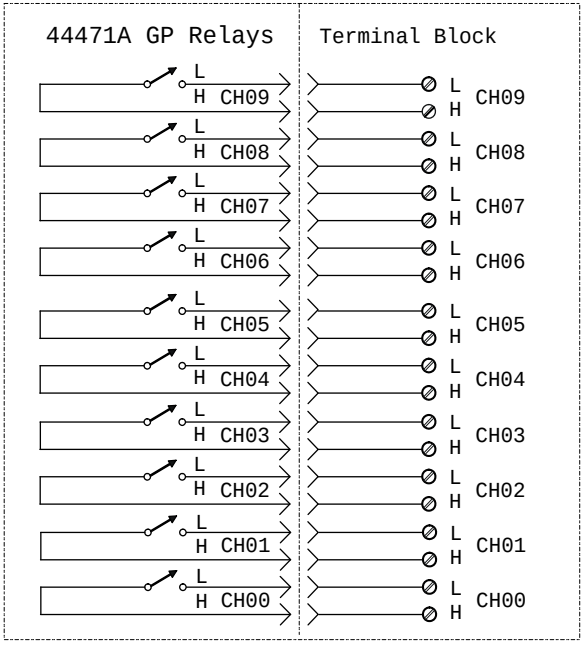
The Agilent 44471A GP Relay Module provides 10 independent Single Pole - Single Throw (SPST, Form A) latching relays. The individual relays on this module are rated for a maximum open circuit voltage of 250 volts dc or ac rms. Maximum current per relay is 2 amps dc or ac rms, and maximum power per relay is 60 watts dc or 125 VA ac. Maximum closed channel resistance is less than 2 Ω.

The 44471A exhibits low thermal characteristics, which make it ideal for independent (non-multiplexed) signal switching. It can be operated in either single channel break-before-make (BBM), or multiple channels closed at the same time.

Specifications for the 44471A are given on page 333.

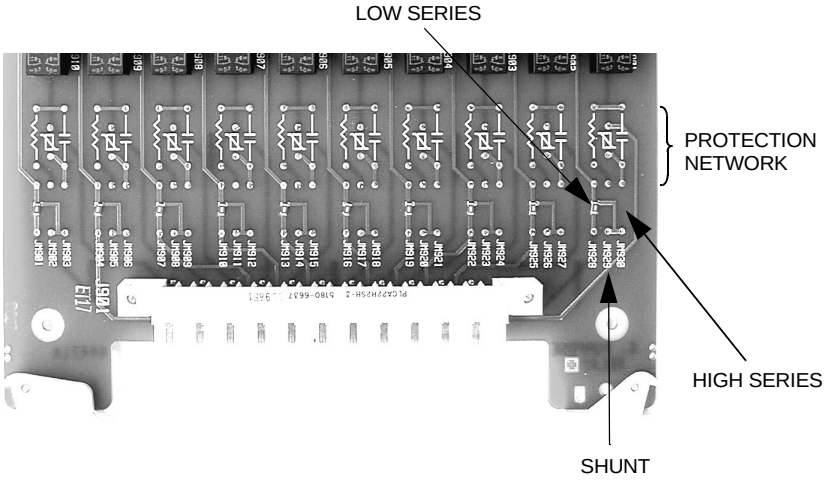
44471A Simplified Schematic

A simplified schematic is shown below. The 44471A consists of 10 independent Single Pole-Single Throw (SPST, Form A) relays. Channels on the 44471A are numbered as 00 through 09 (CH00 through CH09).

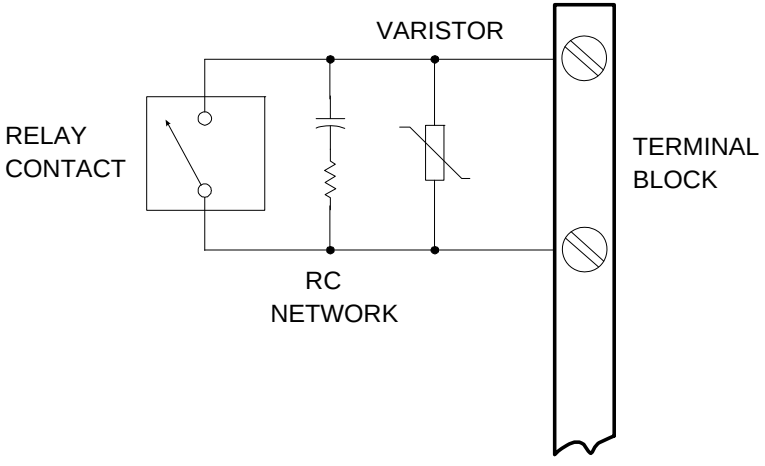


Custom Signal Conditioning

The 44471A circuit board has a provision to allow you to install simple attenuators or filters in the relay paths. There is also a place to install relay contact protection networks. The figure below shows the locations on the main circuit board.



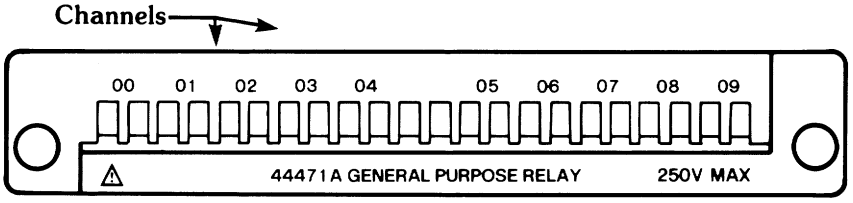
Protection Networks An RC protection network and a varistor can be installed in each relay path. More detailed information about protection circuits is given on page 272.



44471A Wiring Information

Use the Agilent 44481A Terminal Block to make connections to the 44471A. One 44481A is supplied with the module.

The terminal block includes a screw terminal that connects external wiring to the 44471A. The screw terminal is shown below. Additional information about the terminal block is given on page 285.



44471D 20-Channel GP Relay Module

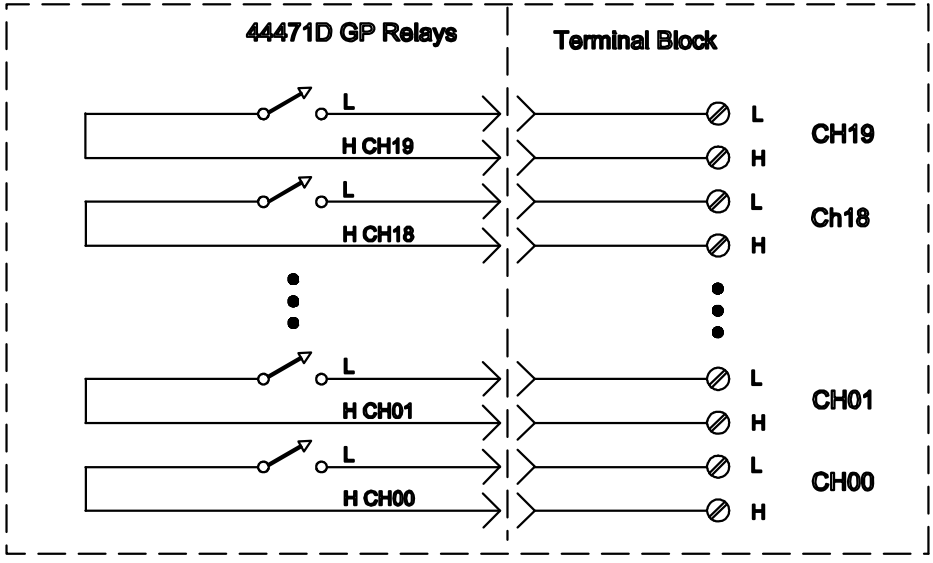
The Agilent 44471D GP Relay module provides 20 independent Single Pole - Single Throw (SPST, Form A) latching relays. Typically used as an actuator assembly, its low thermal characteristics make it ideal for independent (non-multiplexed) signal switching.

The individual relays on this module are rated for a maximum open circuit voltage of 250 volts dc or ac rms. Maximum current per relay is 1 amp dc or ac rms, and maximum power per relay is 60 watts dc or 125 VA ac. Maximum closed channel resistance is less than 2 Ω.

Specifications for the 44471D are given on page 335.

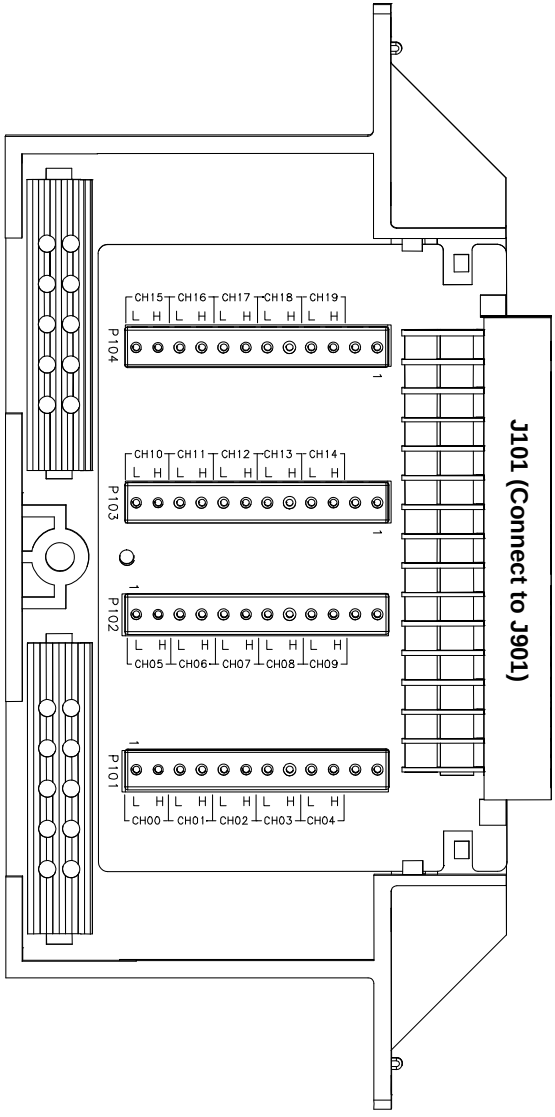
44471D Simplified Schematic

A simplified schematic is shown below. The 44471D GP Relay Module consists of 20 independent SPST (Single Pole - Single Through) relays. Channels are numbered as 00 through 19 (CH00 through CH19).



44471D Wiring Information

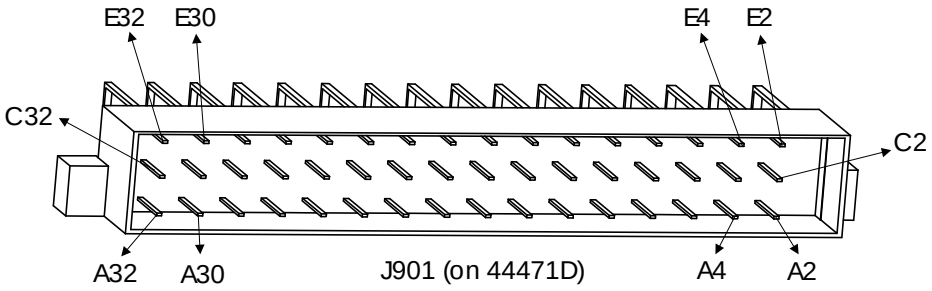
Use the Agilent 44481B Terminal Block to make connections to the 44471D. One 44481B is supplied with the module. The terminal block connectors are shown below. Additional information about the terminal block is given on page 287.


CH15 CH16 CH17 CH18 CH19
L H L H L H L H L H
P104
1
CH10 CH11 CH12 CH13 CH14
L H L H L H L H L H
P103
1
1
P102
L H L H L H L H L H
CH05 CH06 CH07 CH08 CH09
1
P101
L H L H L H L H L H
CH00 CH01 CH02 CH03 CH04
J101 (Connect to J901)

44471D J901 Pinout

J901 is a 3-row, 48-pin male DIN connector mounted on the 44471D. The pin assignments are shown in the figure below

.



J901 A2	CH00 L	A8	CH05 L	A18	CH10 L	A24	CH15 L
C2	CH00 H	C8	CH05 H	C18	CH10 H	C24	CH15 H
E2	CH01 L	A10	CH06 L	E18	CH11 L	A26	CH16 L
E4	CH01 H	C10	CH06 H	E20	CH11 H	C26	CH16 H
A4	CH02 L	E10	CH07 L	A20	CH12 L	E26	CH17 L
C4	CH02 H	E12	CH07 H	C20	CH12 H	E28	CH17 H
A6	CH03 L	A12	CH08 L	A22	CH13 L	A28	CH18 L
C6	CH03 H	C12	CH08 H	C22	CH13 H	C28	CH18 H
E6	CH04 L	A14	CH09 L	E22	CH14 L	A30	CH19 L
E8	CH04 H	C14	CH09 H	E24	CH14 H	C30	CH19 H
E14	NC	C16	NC	E30	NC	C32	NC
A16	NC	E16	NC	A32	NC	E32	NC

E14, A16, C16, E16, E30, A32, C32, E32 NOTCONNECTED (NC)

44472A Dual 4-Channel VHF Switch Module

The Agilent 44472A VHF Switch Module provides two independent 4-to-1 coaxial multiplexers. These multiplexers are specifically designed for broadband signal switching up to 300 MHz. This module is the ideal choice for wide dynamic range measurements with spectrum and distortion analyzers.

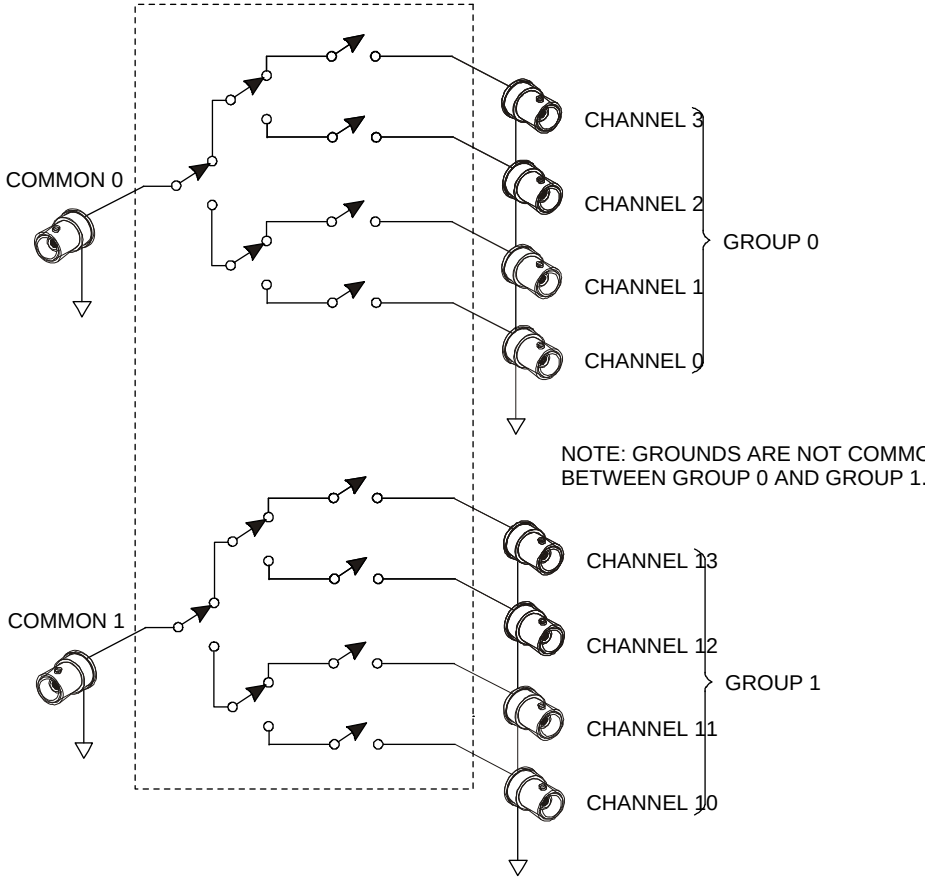
Connections to the module are made through 10 BNC (coaxial) connectors mounted directly on the 44472A. Characteristic impedance is 50 Ω.

Note The 44472A is not recommended for use with instruments that require high DC isolation from earth ground (such as a DMM).

Specifications for the 44472A are given on page 337.

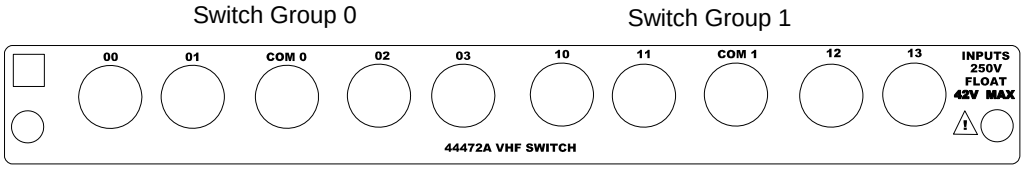
44472A Simplified Schematic

A simplified schematic is shown below. The 44472A VHF Switch module contains of two groups (GROUP 0 & GROUP 1) of 4-to-1 coaxial MUXs. The two groups are isolated from each other and also from the mainframe chassis ground to eliminate ground loops. Furthermore, the shield (or low) of each channel is NOT switched; the shields of the four channels in each group are in common. A tree relay scheme is used to provide higher isolation between channels and from open channels to common. Channels are numbered as 00 through 03 for group 0, and 10 through 13 for group 1.



44472A Wiring Information

Regardless of the topology (configuration) you are using, always use 50 Ω shielded coaxial cables to maintain both characteristic impedance and isolation. Keep cables as short as possible, especially in high frequency circuits or pulse circuits where a rise/fall time of less than 50 nsec is critical. Long cables can add considerable delay time which may cause timing problems. All test equipment (counters, spectrum analyzers, oscilloscopes, etc.) must be terminated with a 50 Ω impedance to minimize reflection loss. The rear panel is shown below.



44473A 4 x 4 2-Wire Matrix Switch Module

The Agilent 44473A Matrix Switch provides a 4 x 4 matrix of 2-wire switches. Each node (crosspoint) in the matrix contains a latching relay that connects a row to a column. Both Hi (H) and Lo (L) lines are switched. More than one switch can be closed at a time, allowing any combination of rows and columns to be connected.

Matrix switching provides a convenient way to connect a group of test instruments to multiple test points on a device or to multiple devices. This matrix switch offers highly flexible switching for testing devices over a frequency range of dc to 100 kHz.

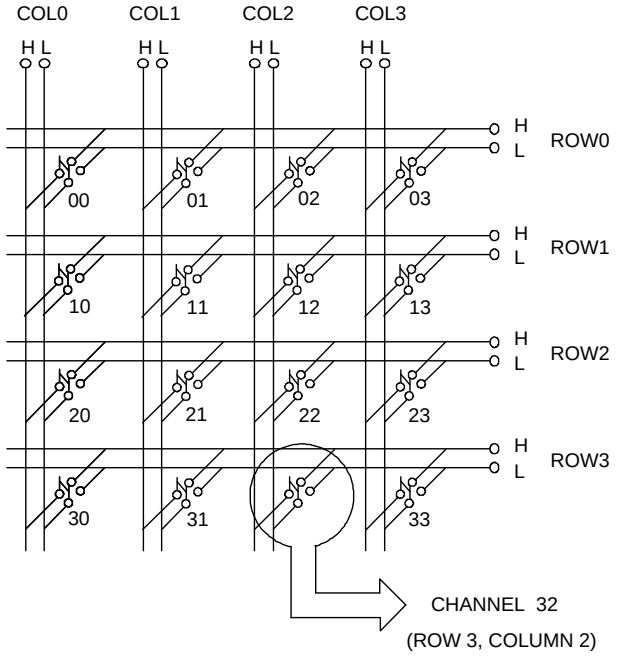
Multiple 44473A modules may be connected together to form a larger matrices. The 44473A can also be used in conjunction with other modules (such as the 44470A 10-Channel MUX) to provide a wide variety of switching combinations. When wiring between multiple modules, keep wire length as short as possible to minimize noise and signal degradation.

Specifications for the 44473A are given on page 339.

44473A Simplified Schematic

A simplified schematic is shown below. The 44473A consists of 16 2-wire relays (nodes/crosspoints) organized in a 4-row by 4-column matrix.

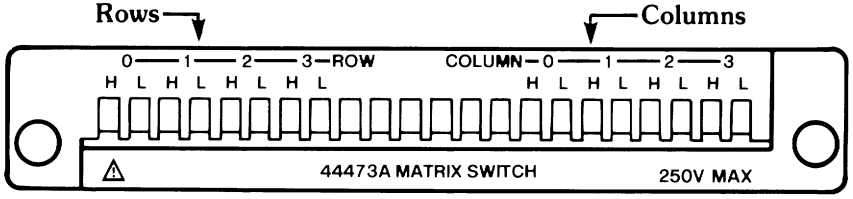
Channels in this matrix module are numbered in the Row-Column format. For example, channel 32 represents the crosspoint connection between row 3 and column 2; while the channel 23 represents the crosspoint connection between row 2 and column 3, and so on.



44473A Wiring Information

Use the Agilent 44483A Terminal Block to make connections to the 44473A. One 44483A is supplied with the module.

The terminal block includes a screw terminal that connects external wiring to the 44473A. The screw terminal is shown below. Additional information about the terminal block is given on page 285.



44474A 16-Bit Digital I/O Module

The Agilent 44474A Digital I/O module provides 16 bidirectional data lines (bits) plus 4 lines used for control and handshaking. All lines are TTL compatible. The 16 I/O lines or bits can be addressed individually (bit-by-bit), as two independent 8-bit ports, or as one 16-bit word.

The two 8-bit ports are completely independent of each other and may be used separately. For instance, one port can be used for output operations, while the other for input. However, all 8 bits in a given port must be either input or output bits (not a combination of input and output).

Five handshaking modes are available for this module. The handshaking modes are described beginning on page 98. Handshaking uses up to three control lines:

- Peripheral Control (PCTL)
- I/O direction (I/O)
- Peripheral Flag (PFLG or EI)

Additionally, the 44474A provides an additional Channel Closed (CC) line that changes state to indicate a channel has been closed. The External Increment (EI) and Channel Closed (CC) lines can be used to control an external instrument such as a DMM. For example, Agilent DMMs have a Voltmeter Complete line that indicates when a measurement has completed. This line is connected to the 44474A EI input and the Channel Closed output is connected to the DMM External Trigger. When properly configured, a scan list can then be executed and measured without external computer control.

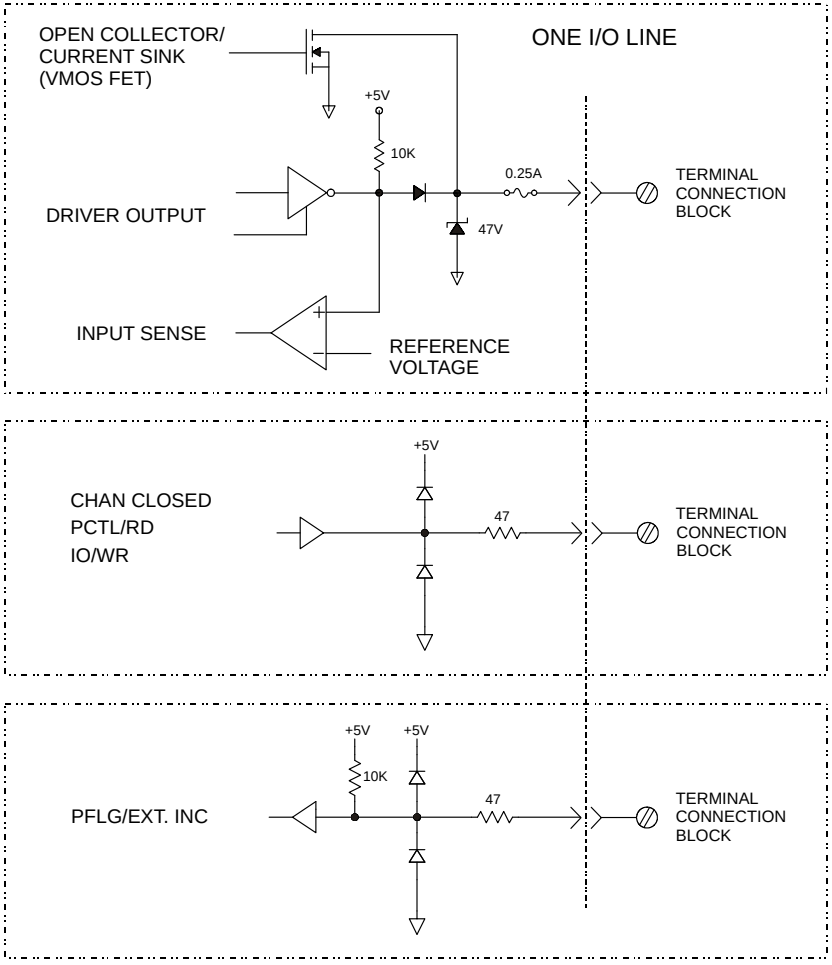
Port and bit numbering is show in the table below. Note that the ports are numbered differently if you are using the 3488 System mode.

System Mode	16-Bit Port #	8-Bit Port #	Bit #
SCPI mode	PORT 00	PORT 00	Bits 0-7 (LO BYTE)
		PORT 01	Bits 0-7 (HI BYTE)
3488A Mode	PORT 02	PORT 00	Bits 0-7 (LO BYTE)
		PORT 01	Bits 0-7 (HI BYTE)

Specifications for the 44474A are given on page 341.

44474A Simplified Schematic

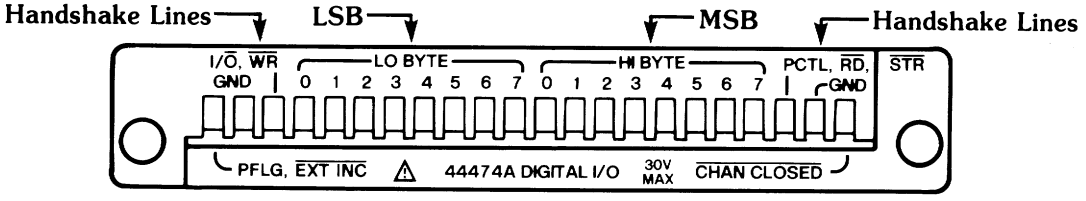
A simplified schematic is shown below. Note that all 16 I/O lines and 4 control lines share a common Lo connection. The 16 bits (I/O lines) are numbered as bits 0 through 15 when the module is addressed individually. The bits 0-7 refer to the bits 0-7 of the LO BYTE, and the bits 8-15 refer to the bits 0-7 of the HI BYTE.



44474A Wiring Information

Use the Agilent 44484A Terminal Block to make connections to the 44474A. One 44484A is supplied with the module.

The terminal block includes a screw terminal that connects external wiring to the 44474A. The screw terminal is shown below. Additional information about the terminal block is given on page 285.



44475A Breadboard Module

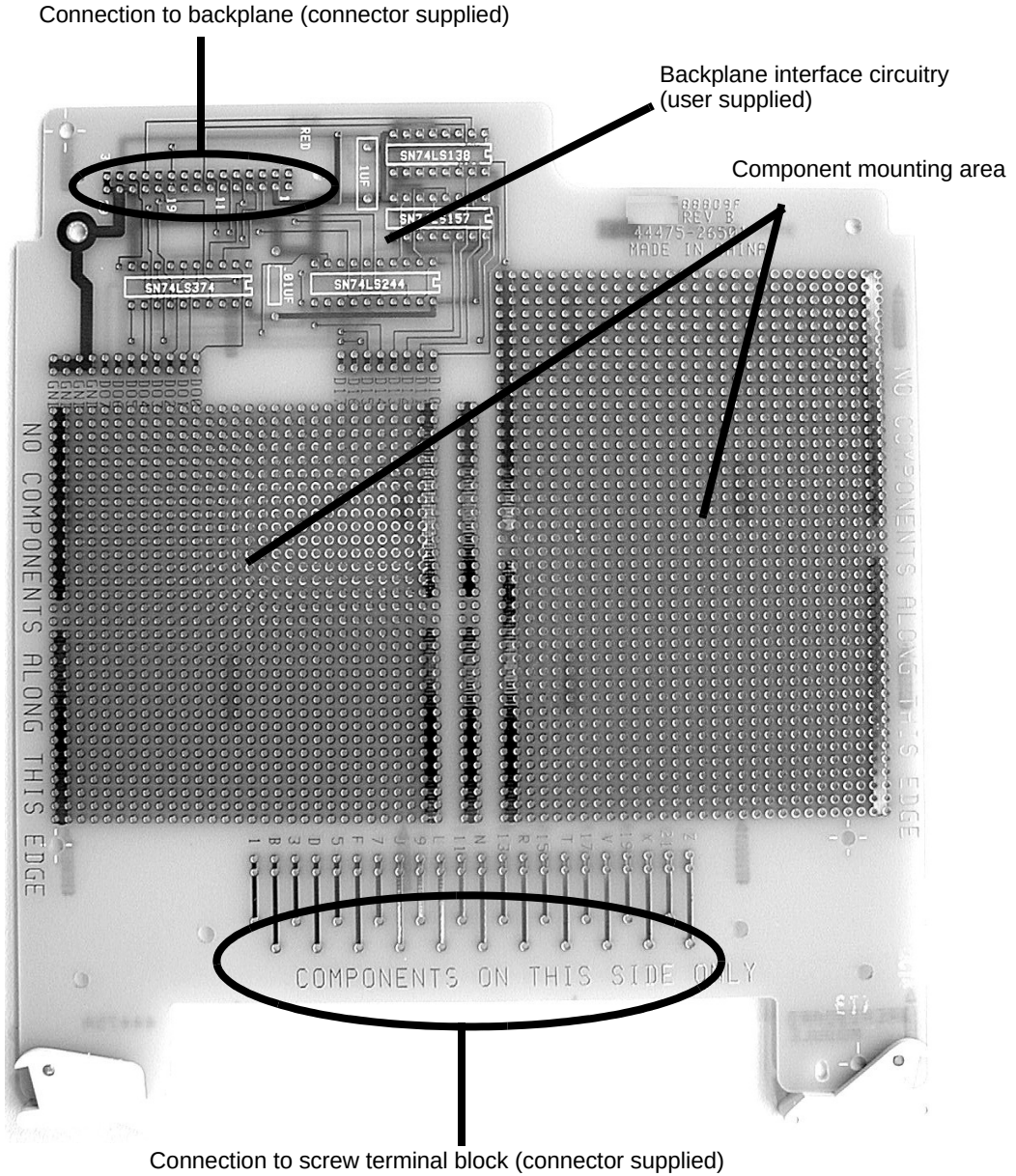
The Agilent 44475A Breadboard module provides a means to mount custom designed circuits for use in the mainframe. If a desired function is not be available on a standard plug-in module, the 44475A provides the ideal solution.

Components are specified (but not supplied with the Breadboard module) for interfacing the Breadboard to the 3499A/B/C backplane. When these components are used, the Breadboard then provides 8 static input and 8 static output lines.

Two commands are used to control the Breadboard; DIAG:SPEEK? reads data from the input port and DIAG:SPOKE writes data to the output port. These commands are described on page 131.

Specifications for the 44475A are given on page 342.

The 44475A circuit board is shown below.

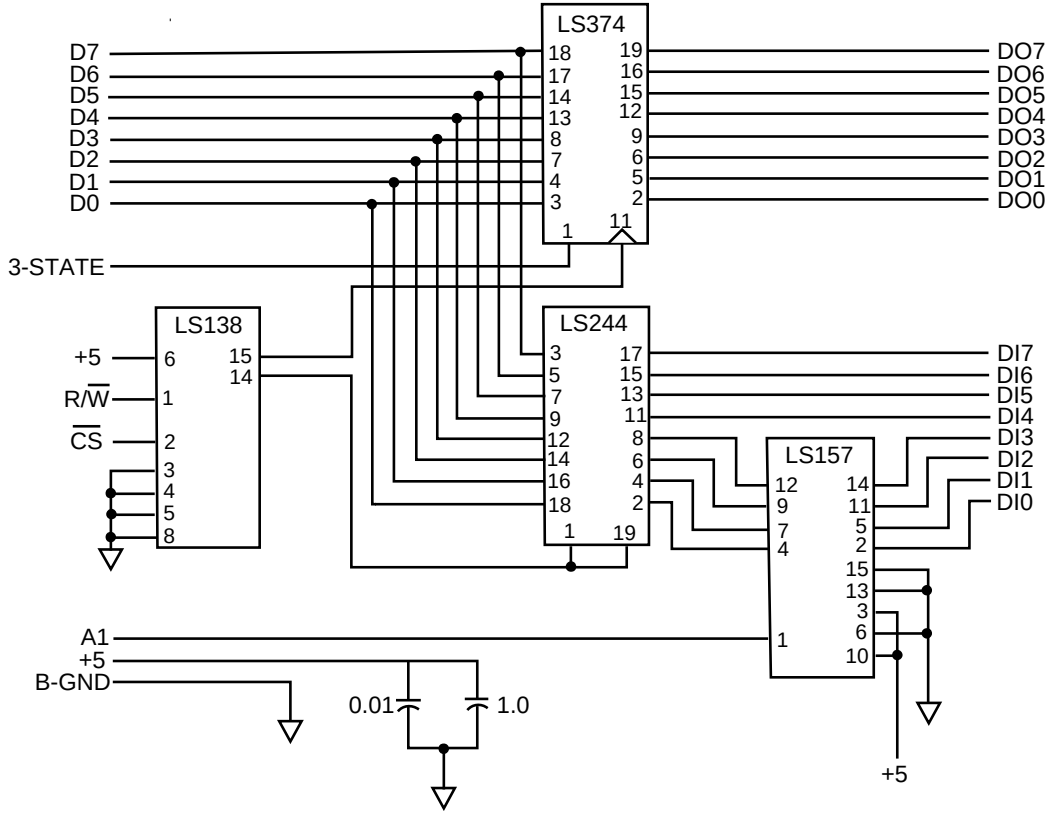


44475A Simplified Schematic

A simplified schematic of the breadboard interface is shown below. The 44475A is divided into two areas. They are:

1. Breadboarding Grid consisting of holes on 0.10 inch centers. There is 0.030 inch spacing between foil pads. Bus traces for power supply and ground, and provisions for the screw terminal block edge connector are provided.

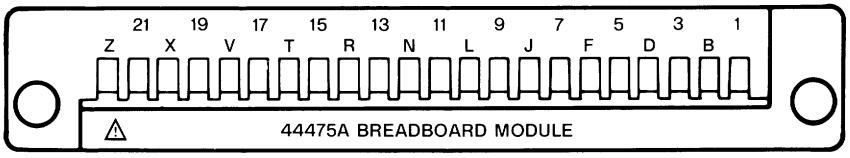
2. Built-in design for providing an 8-bit digital input port and an 8-bit digital output port.



44475A Wiring Information

Use the Agilent 44485A Terminal Block to make connections to the 44475A. One 44485A is supplied with the module. Included with the terminal block is a numbered label you can apply for slot identification.

The terminal block includes a screw terminal that connects external wiring to the 44475A. The screw terminal is shown below. Additional information about the terminal block is given on page 285.



Assembling the Breadboard

Assemble the 44475A Breadboard using the following steps:

1 Load the components for the 8-bit Input and 8-bit Output ports.

Components were not supplied (but are listed in the table below). You can obtain these components from any supplier. The figure on page 252 shows where these components are to be mounted on the Breadboard.

Quantity	Component	Description
1	SN 74LS138	3 to 8 line decoder
1	SN 74LS157	Quad 2 to 1 line data selector/multiplexer (noninverted data outputs)
1	SN 74LS244	Octal Butters, line drivers, line receivers (noninverted 3-state outputs)
1	SN 74LS374	Octal D-Type Flip-Flops (3-state outputs)
1		0.01 uF Capacitor, 10 volts
1		1 uF Capacitor, 10 volts

2 Install your custom circuitry.

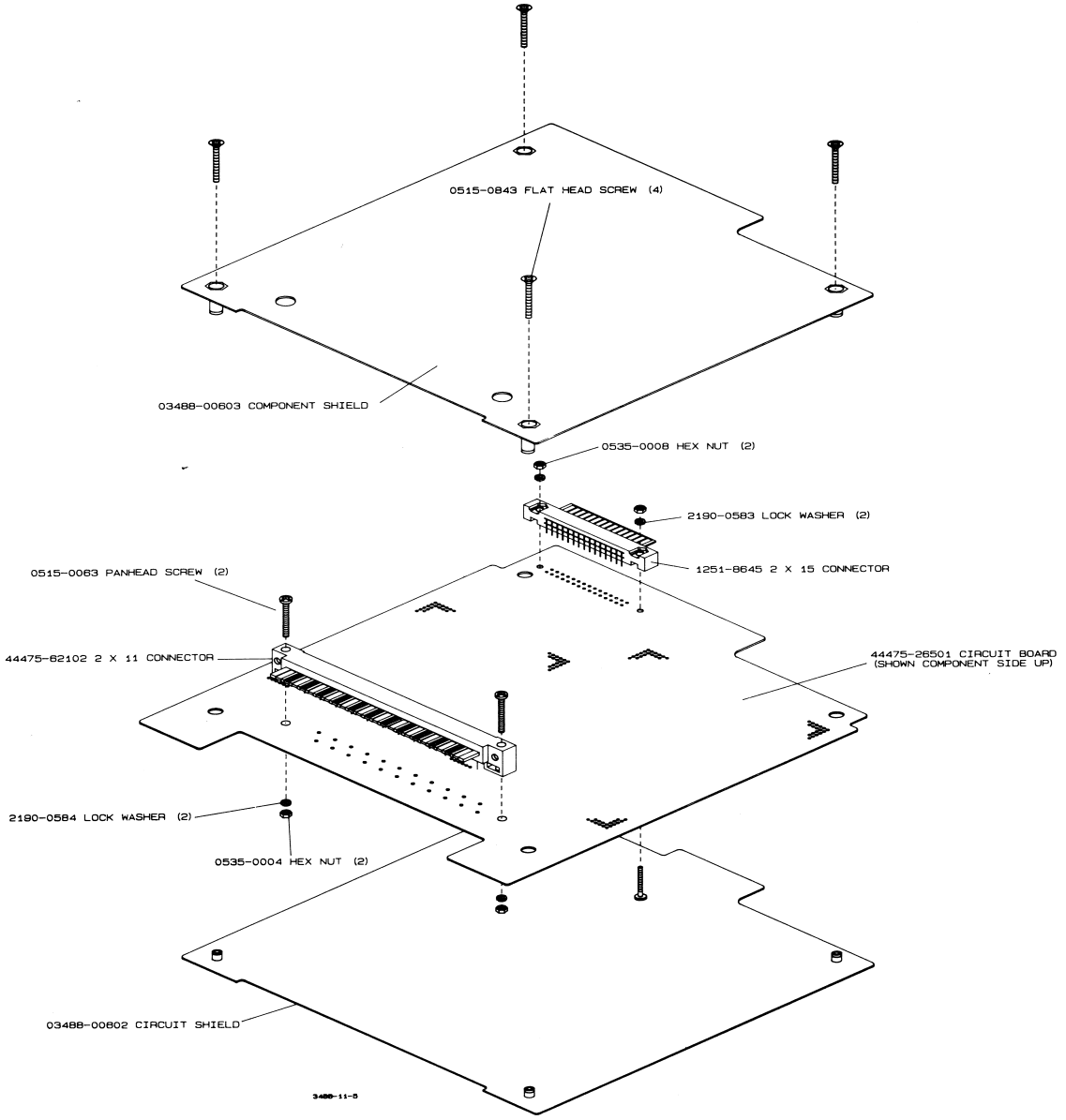
Component height restrictions and how far the component leads extend through the circuit board are limited by the top and bottom shields. These shields provide RF shielding as well as structural strength and must never be eliminated.

The maximum component height allowed is 12.7 mm (0.50 in.). However, if the height of any component exceeds 10 mm, the conductive surface of the component must be insulated. On the circuit side of the Breadboard, the lead lengths are limited to 3.2 mm (0.125 in.) from the circuit board.

3 Assemble the hardware.

The table below lists the hardware parts that are supplied with the 44475A. An assembly diagram is given on the next page.

Part Number	Description
44475-26501	Breadboard circuit board
03488-00602	Bottom shield
03488-00603	Top shield (component side)
1251-8645	2 rows x 15 pins right angle connector (small connector)
44475-62102	2 rows x 11 pins right angle connector (large connector)
44475-62101	Terminal Block, keyed for the breadboard connector
5040-5193	Connector Housing
0515-5194	Cable Clamp
0515-0063	Pan Head screw, 2.5 x 12 (metric)
0515-0843	Flat Head screw, 2.5 x 20 Lock (metric)
0515-0045	Pan Head screw, 3 x 18 Lock (metric)
0535-0004	Hex Nut, 3 x 0.5
0535-0008	Hex Nut, 2.5 x 0.45
2190-0583	Lock Washer
2190-0584	Lock Washer


0515-0843 FLAT HEAD SCREW (4)
03488-00603 COMPONENT SHIELD
0535-0008 HEX NUT (2)
2190-0583 LOCK WASHER (2)
1251-8645 2 X 15 CONNECTOR
0515-0063 PANHEAD SCREW (2)
44475-82102 2 X 11 CONNECTOR
44475-26501 CIRCUIT BOARD
(SHOWN COMPONENT SIDE UP)
2190-0584 LOCK WASHER (2)
0535-0004 HEX NUT (2)
03488-00602 CIRCUIT SHIELD
3488-11-5

44476A Microwave Switch Module

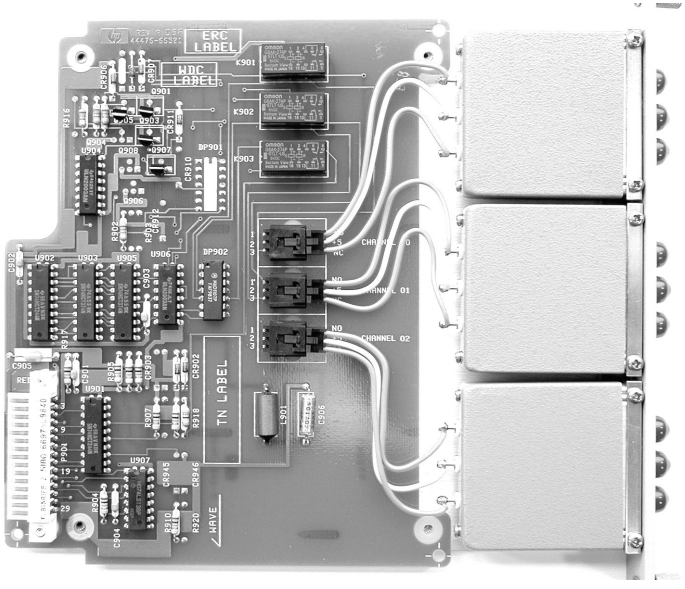
The 44476A contains three Microwave Switches. These switches have the following features:

- Broad bandwidth (dc to 18 GHz)
- High isolation (> 90 dB to 18 GHz)
- Excellent repeatability (typically 0.03 dB after 1,000,000 switchings)
- Internal 50 Ω terminations

The Agilent 8762B is a break-before-make switch controlled by a latching solenoid. Once switched, coil voltage can be removed and the switch remains in the switched position. Internal coil contacts open and remove coil voltage after a switching operation to minimize the amount of heat dissipated near the switch contacts. The Agilent 8762B uses SMA connectors for ease in cable connections

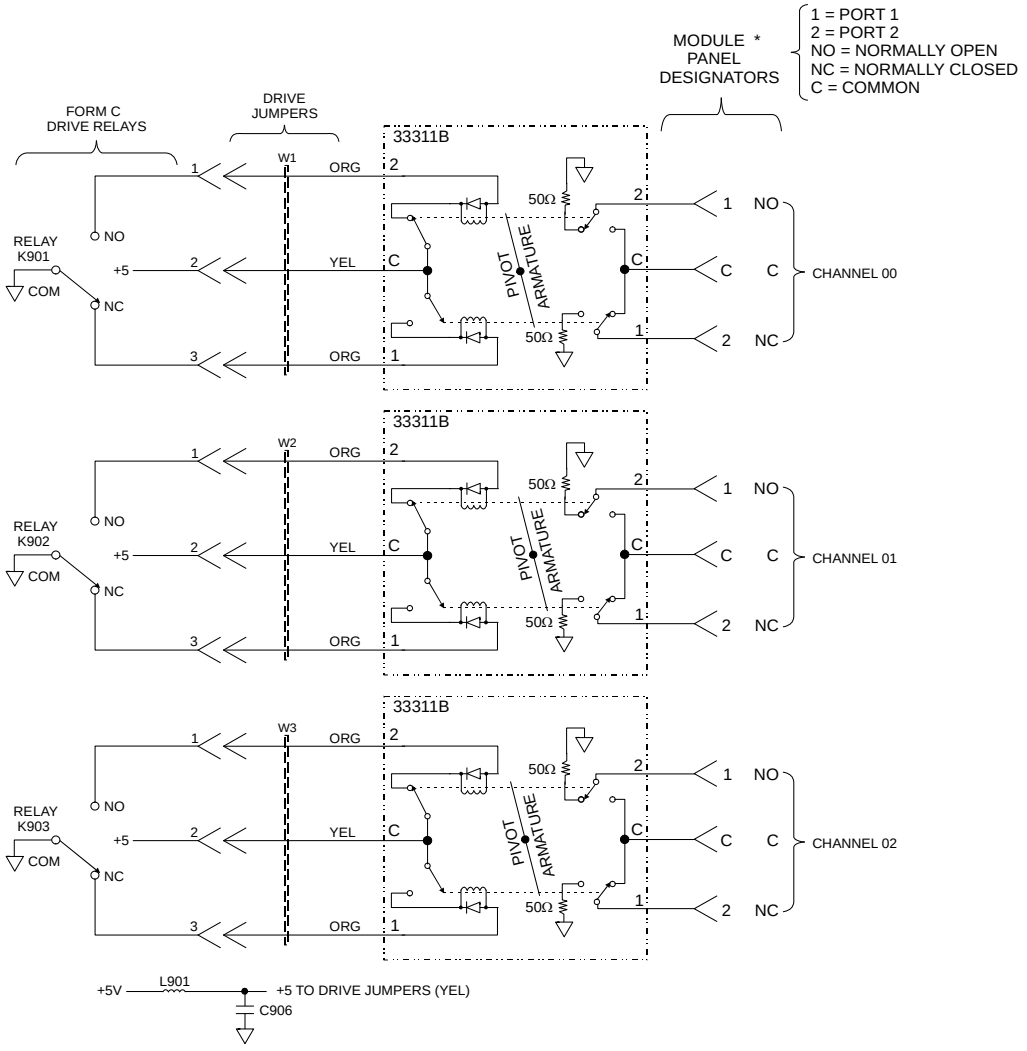
The 3499A/B/C identifies this module as a 44471A on the front-panel display. Changing the state of channels other than channels 00 through 02 does not generate an error, but has no effect.

Specifications for the 44476A are given on page 344.



44476A Simplified Schematic

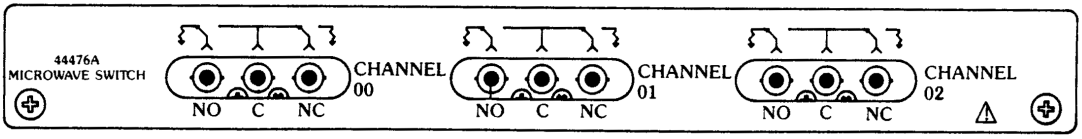
A simplified schematic is given below. The 44476A contains three 8762B Microwave Switches. Each microwave switch is referred to as a channel. The channels on the 44476A are numbered as 00, 01, and 02.



* NOTE :
TERMINAL DESIGNATIONS INSIDE THE DASHED BOXES REFER TO THE 33311B ONLY. MODULE PANEL DESIGNATORS OUTSIDE THE DASHED BOXES ARE THOSE SILKSCREENED ON THE 44476A PANEL. ANY REFERENCE IN THIS MANUAL TO A PORT REFERS TO THE MODULE PANEL DESIGNATORS.

44476A Wiring Information

The 44476A provides nine 50 Ω SMA connectors.



44476B Microwave Switch Module

The 44476B is not supplied with microwave switches. You must provide your own microwave switches, mount them on the assembly, and connect one of the module's Form C relay drive circuits to each switch.

The 44476B panel has two 53.8 X 9.6 mm cutouts for a set of microwave switches. The recommended Agilent microwave switches are listed below.

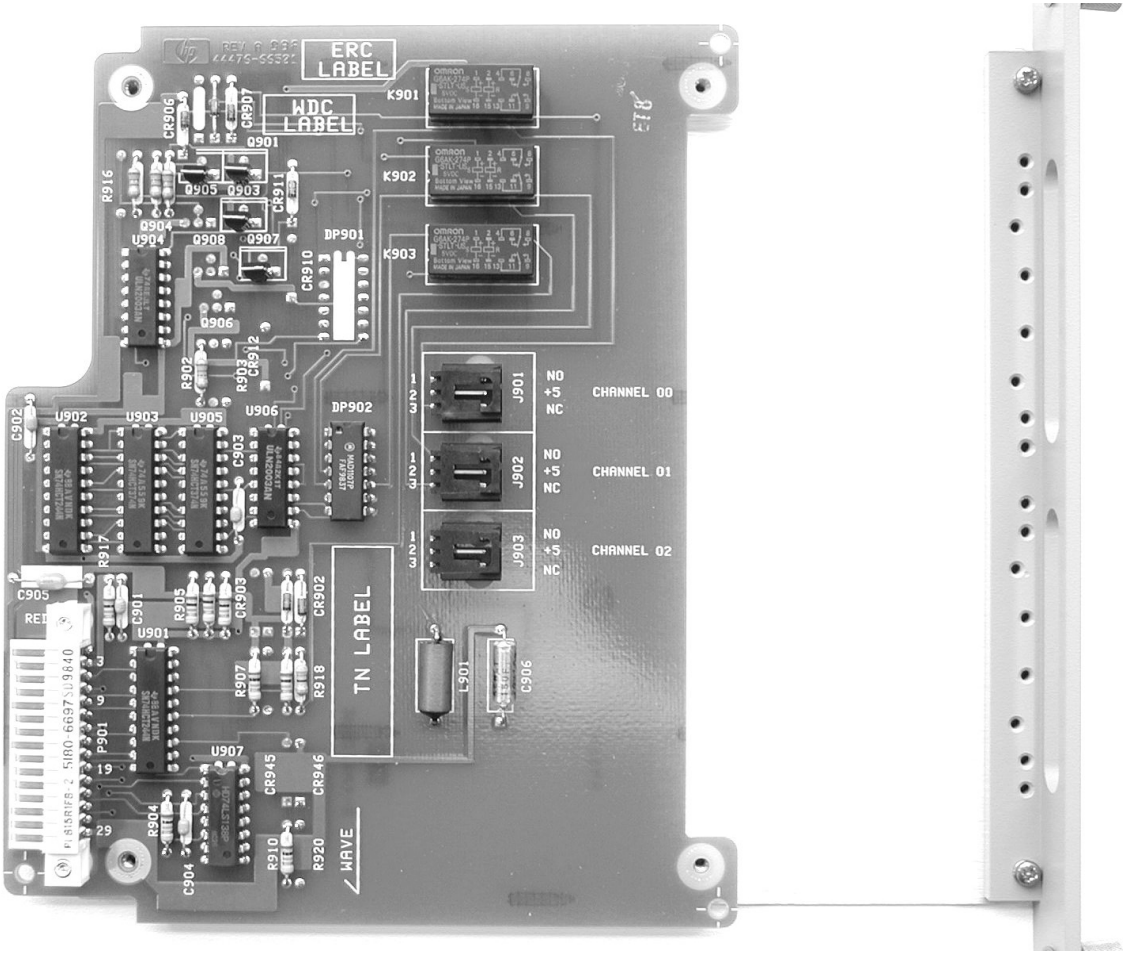
Microwave Switch	Ports	Frequency
8762A	3	DC-4 GHz
8762B	3	DC-18 GHz
8762C	3	DC-26.5 GHz
8762F[a]	3	DC-4 GHz
8763B	4	DC-18 GHz
8763C	4	DC-26.5 GHz
8764B	5	DC-18 GHz
8764C	5	DC-26.5 GHz

a. Except the 8762F Microwave Switch with 75 Ω characteristic impedance, all others are 50 Ω.

The 3499A/B/C identifies this module as a 44471A on the front-panel display. Changing the state of channels other than channels 00 through 02 does not generate an error, but has no effect.

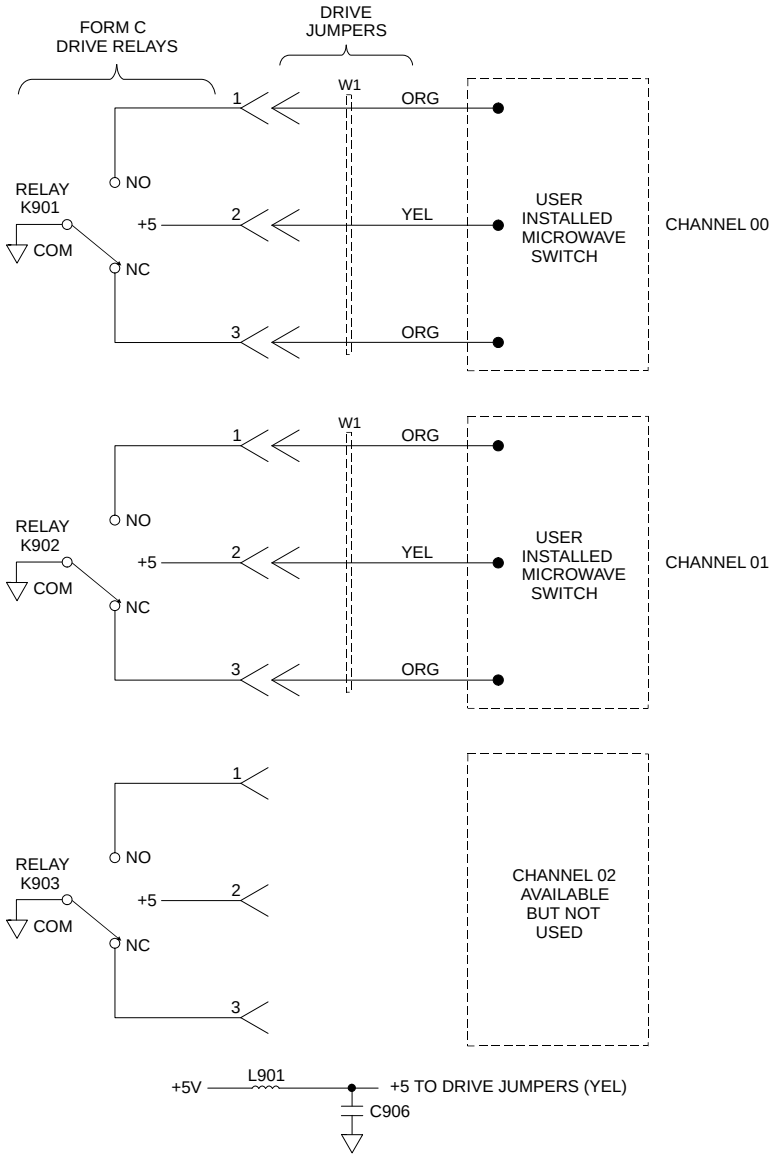
Specifications for the 44476B are dependent upon the switches used. Refer to the switch data sheets for more information.

The 44476B is shown below.



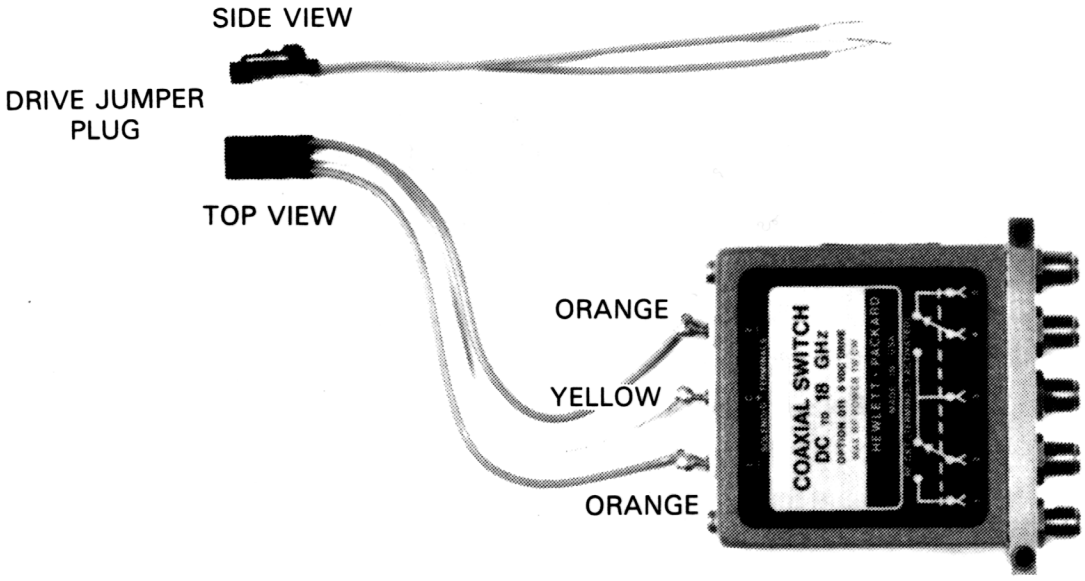
44476B Simplified Schematic

A simplified schematic of the 44476B is shown below. You must provide your own microwave switches and mount them on the assembly. The channel are numbered channels 00 and 01.

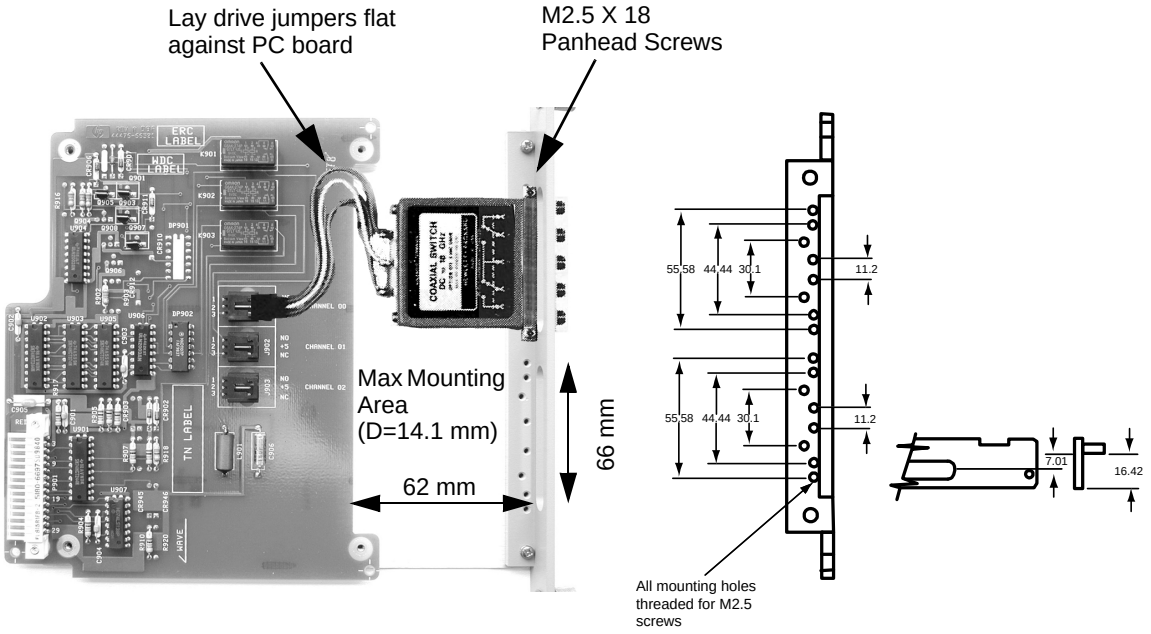


Configuration

Mount user-supplied microwave switches on the module after connecting the channels 00 and 01 drive jumpers (W1 and W2). The figure below shows the drive jumper orientation.

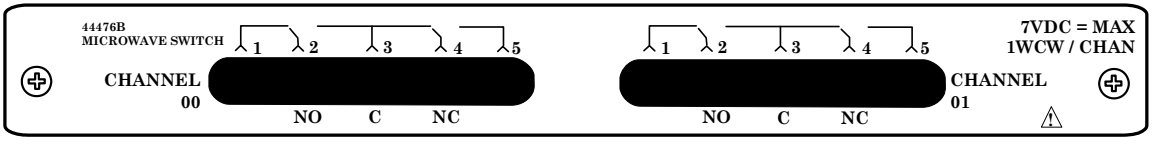


The figure below shows an Agilent 8764B 5-port switch mounted on the 44476B.



44476B Wiring Information

The user-provided switches use 50 Ω SMA connectors (except the Agilent 8762F which uses 75 Ω SMA connectors).



44477A Form-C Relay Module

The Agilent 44477A consists of seven independent, break-before-make, SPDT Form-C latching relays (one contact normally open, one contact normally closed).

The 44477A can be used for signal switching or power applications (250V, 2A). Additionally, this module is ideally suited for driving remote RF, coaxial, and microwave devices such as the Agilent 8761, 8762A/B/C, 8763B/C, and 8764B/C switches or programmable step attenuators like the 876xx series.

You can use the 3499A/B/C +5 V power supply available on the module or provide an external supply to use as pull-ups on either the NO or NC paths.

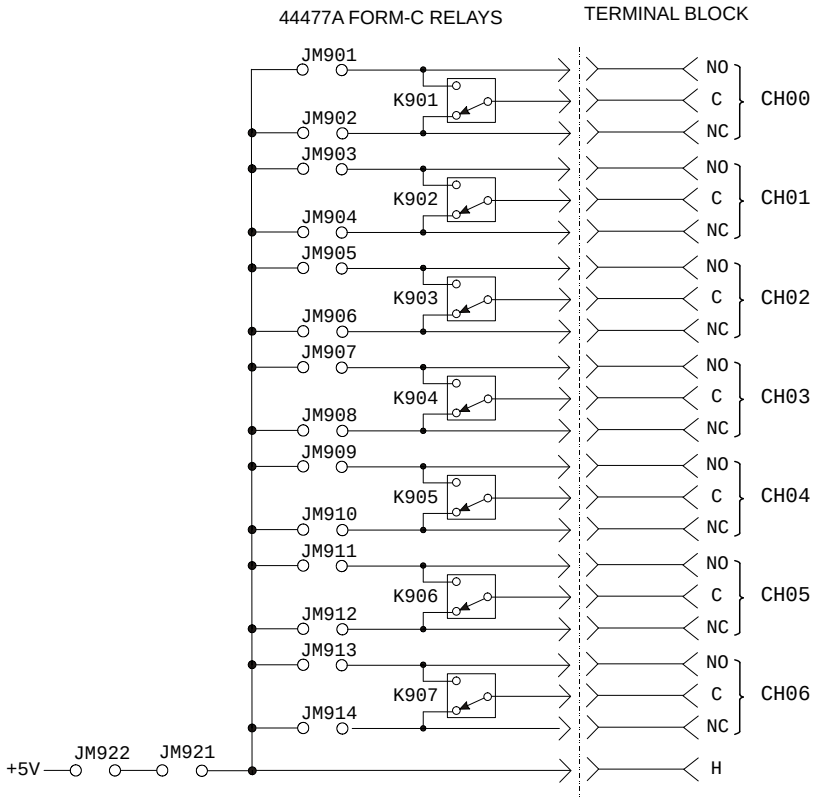
The 3499A/B/C identifies this module as a 44471A on the front-panel display. Changing the state of channels other than channels 00 through 06 does not generate an error, but has no effect.

Specifications for the 44477A are given on page 345.

44477A Simplified Schematic

A simplified schematic is given on the next page. The 44477A consists of seven independent Form-C relays (K901-K907) which are numbered as channels 00 through 06. Closing a channel (relay) will connect the normally open (NO) contact to the common port (C). After power-on or a reset, the Form C relays on the 44477A have their normally open (NO) contacts open and normally closed (NC) contacts closed.

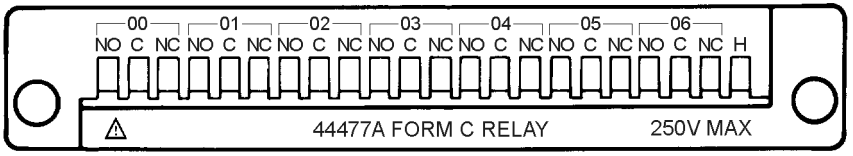
Each relay circuit has mounting holes (JM901 - JM914) used to add a pull-up resistor from the NO (normally open) and/or NC (normally closed) contacts to the +5V power supply. Also, there are mounting holes (JM921 and JM922) at the +5V supply for the addition of a protection resistor or inductor if the internal supply is to be used. If the internal supply is not used, an external power supply can be applied through the screw terminal block via the “H” terminal. The addition of pull-up resistors can be useful when driving logic circuits where the common (C) terminal is connected to ground and used to pull either the NO or the NC line low.



44477A Wiring Information

Use the Agilent 44487A Terminal Block to make connections to the 44477A. One 44487A is supplied with the module. Included with the terminal block is a numbered label you can apply for slot identification.

The terminal block includes a screw terminal that connects external wiring to the 44477A. The screw terminal is shown below. Additional information about the terminal block is given on page 285.



44478A/B 1.3 GHz Dual 4-to-1 MUX Modules

The Agilent 44478A and 44478B consist of two independent 4-to-1 multiplexers (group 00 and group 01) that provide bidirectional switching. The module's latching relays are configured in a "tree" structure, to provide high isolation and low VSWR (voltage standing wave ratio). Each channel can switch up to 42V dc + ac peak at frequencies up to 1.3 GHz.

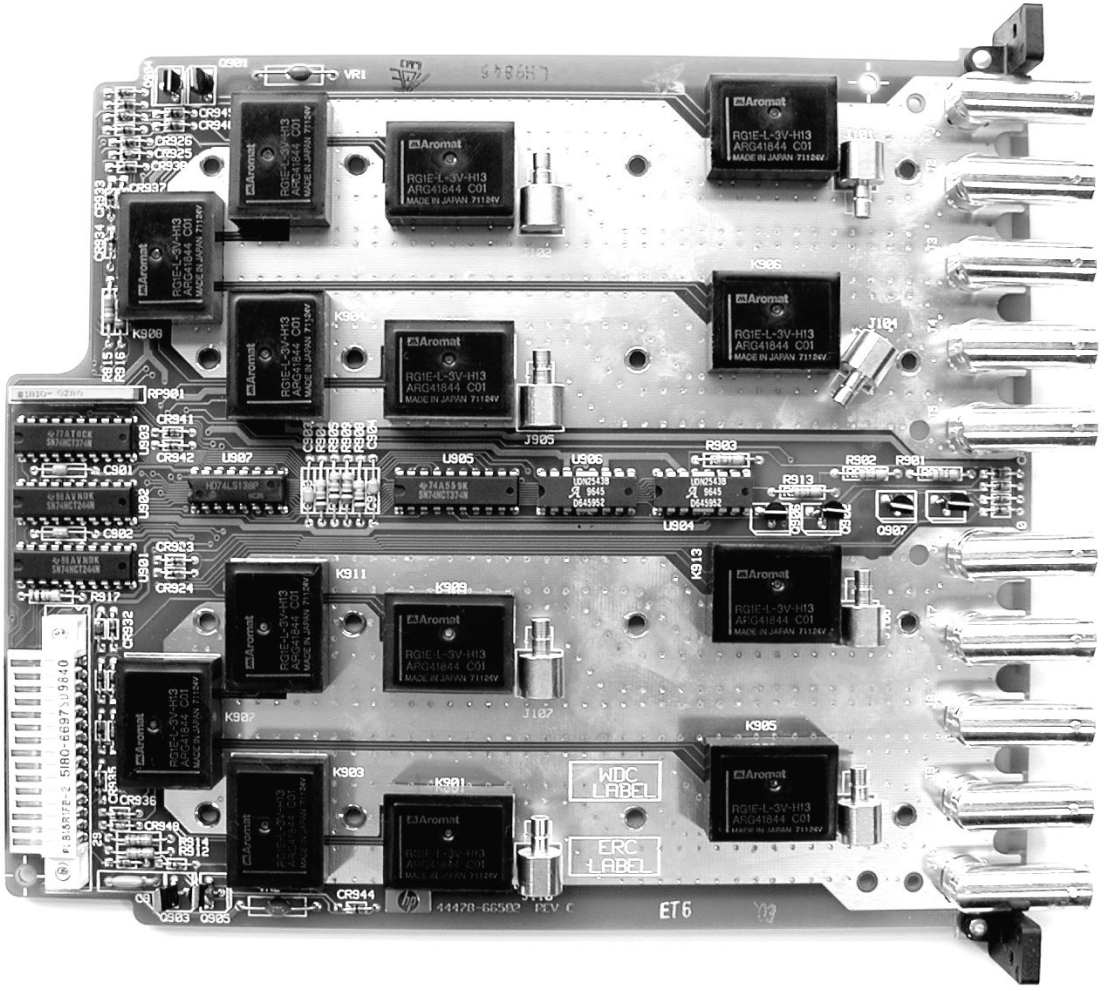
The 44478A is intended for 50 Ω impedance applications.
The 44478B is intended for 75 Ω impedance applications.

User connections for the channels are through BNC connectors on the rear panel. Each channel has an SMB connector on the main PC board used to connect resistive terminations and terminate unused channels.

The 3499A/B/C identifies this module as a 44472A on the front-panel display. Changing the state of channels other than channels 00 through 03 or 10 through 13 does not generate an error, but has no effect.

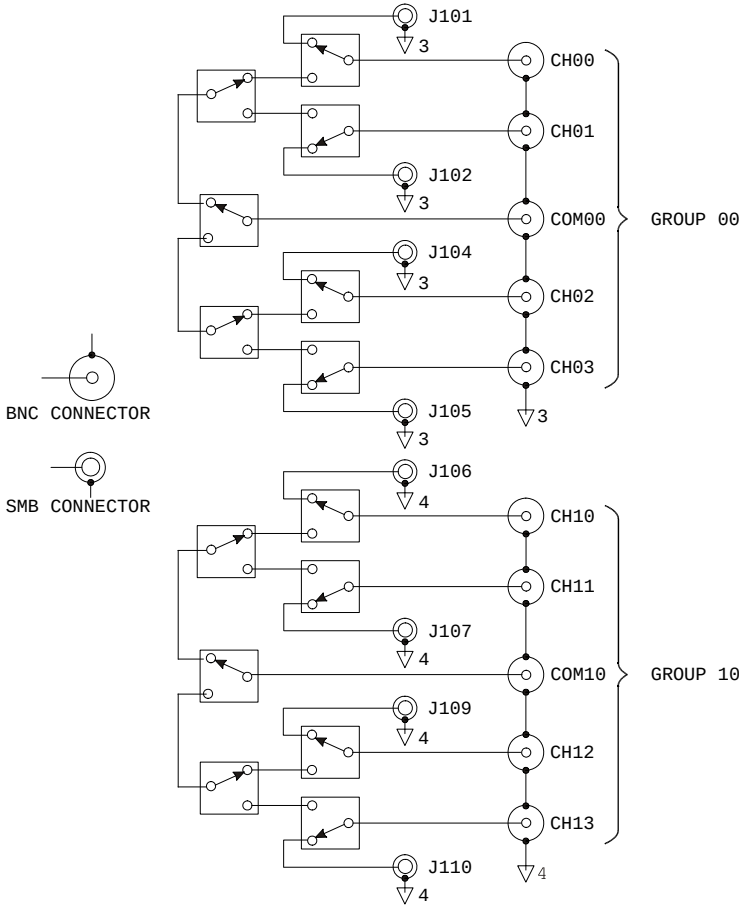
Specifications for the 44478A/B are given on page 347.

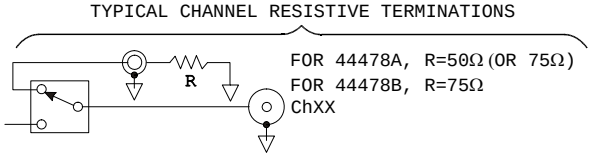
The 44478A/B is shown below.



44478A Simplified Schematic

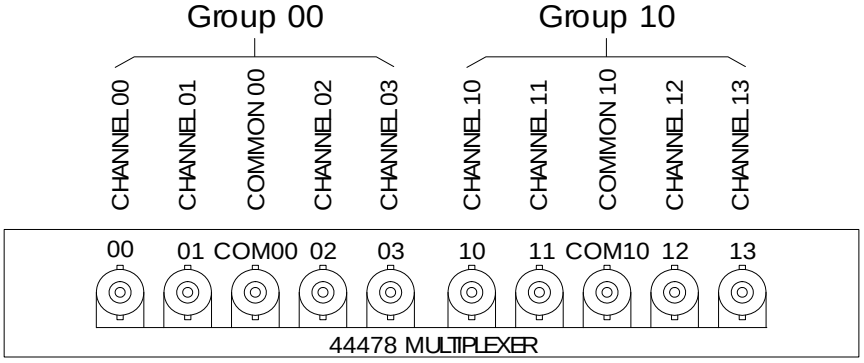
A simplified schematic is shown below. The two groups of 4-to-1 MUXs are specified as GROUP 00 and GROUP 10. They are isolated from each other. Closing a channel closes a particular set of relays to connect the common BNC to one of the four BNC inputs. Channels within each group are break-before-make and are numbered as 00 through 03 for GROUP 00 and 10 through 13 for GROUP 10.





44478A Wiring Information

External Wiring The figure below shows the module's female BNC connectors and the channel group numbers. The BNC connectors accept user-supplied male BNC connectors.



Terminations The figure on page 268 shows the SMB connectors on the main PC Board. The SMB connectors allow you to connect SMB resistive terminations to any unused channels. SMB resistive terminations are available from Agilent using the following part number:

- 34585A (set of four 50 Ω terminations for the 44478A)
- 34586A (set of four 75 Ω terminations for the 44478B)

Note

To maintain proper operation, unused channels should be terminated by plugging a 50 Ω or 75 Ω SMB type resistive termination (50 Ω for 44478A and 75 Ω for 44478B) onto the male SMB connector provided for each channel.

Cabling Considerations

RG-223/U cable is recommended. Ready-made cables (BNCs on both ends) are available from Agilent using the following part numbers:

- **8120-1838:** 30 cm (12 in.), 50 Ω coaxial
- **8120-1839:** 61 cm (24 in.), 50 Ω coaxial
- **8120-1840:** 122 cm (48 in.), 50 Ω coaxial
- **5062-6452:** 30 cm (12 in.), 75 Ω coaxial

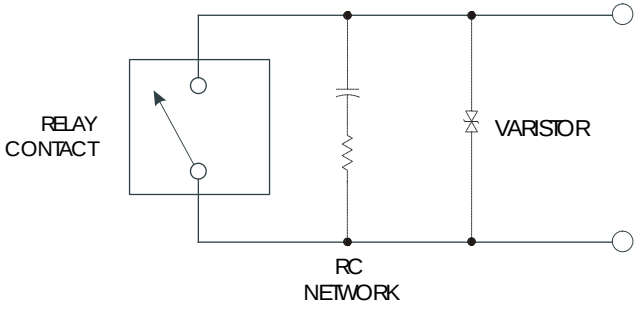
Always use shielded coaxial cables with the characteristic impedance of the module used (50 Ω or 75 Ω). Keep cables as short as possible, especially in high frequency circuits or pulse circuits where a rise/fall time of < 50 nS is critical. Long cables can add considerable delay time which can cause timing problems. All test equipment such as counters, spectrum analyzers, oscilloscopes, etc., must be terminated in the characteristic impedance to minimize reflection loss.

Protection Networks

This information applies specifically to the N2267A (page 206) and 44471A (page 236) multiplexer modules. These multiplexers have provisions built in to allow you to add custom protection networks. This information is general and may be used to help you design other relay protection circuits.

Protection networks are especially needed if the loads being switched are inductive loads such as incandescent lamps or electric motors. The resistance of these loads is very low when the power is first applied (for example, the transient inrush current when switching on a lamp could be 15 times the steady-state value). When switching off inductive loads, the counter EMF of the coil can generate high voltage across the relay contacts, and may damage the contacts.

Current limitation circuitry should be used to prevent relay contacts from being damaged. Space to mount a protection network is designed on the PC board to avoid this damage. Either an RC network or a varistor can effectively absorb the high voltage surge. The specifications of protection components are determined by the loads that are connected to the multiplexer. A typical protection circuit for relay contacts is illustrated below.



In designing RC protection networks, the protection resistor, R_p, is selected as a compromise between two values. The minimum value of R_p is determined by the maximum acceptable relay contact current (Io). The maximum allowable relay current (Io) is 2 amps ac rms or 2 amps dc. Thus, the minimum value for R_p is V/Io, where V is the peak value of the supply voltage.

$$R_p = V/Io = V/2 \qquad \textit{Equation 1}$$

The maximum value for R_p is usually made equal to the load resistance, RI. Therefore, the limits on R_p can be stated as:

$$V/Io < R_p < RI \qquad \textit{Equation 2}$$

Note, the actual value of Io in a circuit is determined by the equation:

$$Io = V/RI \qquad \textit{Equation 3}$$

Where V is the peak value of the source voltage and RI is the resistance of the load. Equations 1 & 2 use Io as the maximum allowable relay current to determine the minimum value of R_p. The value for Io calculated in Equation 3 will be used to determine the value of the protection capacitor, C_p.

In determine the value of the protection network capacitor C_p, there are several things that need to be considered. First, the total circuit capacitance (C) must be such that the peak voltage across the open relay contacts does not exceed 353 volts peak (250 V rms = 353 Vp). The equation for determining the minimum allowable circuit capacitance is:

$$C \geq (Io/353)^{2L} \qquad \textit{Equation 4}$$

where L = the inductance of the load and Io is the value calculated in Equation 3.

In reality, the total circuit capacitance (C) is made up of the wiring capacitance plus the value of the protection network capacitor C_p. Therefore, the minimum value for C_p should be the value obtained for the total circuit capacitance, C, from Equation 4. Indeed, the actual value used for C_p should be substantially greater than the value calculated for C.

For example, we will determine the typical values for an RC protection network where the load is a small ac motor running on the 120 V ac line (170 V peak). This motor draws a maximum of 2 amps.

Using Equation 1 we can find the minimum value for R_p:

$$R_p = V/Io = 170/2 = 85\ \Omega$$

The maximum value for R_p would be equal to the load resistance or 400 Ω. Therefore, any resistor (preferably at least 1 watt) between 85 and 400 Ω will suffice.

To keep the peak contact voltage below 353V peak, use equation 3 to determine Io:

$$Io = V/R1 = 170/400 = 0.425\ A$$

Now use equation 4 to determine C:

$$C \geq (Io/353)^{2L} = (0.425/353)^{2(0.1)} = 0.144\ \mu F$$

Since R_p can vary between 85 Ω and 400 Ω, an appropriate protection network to be connected to this circuit is R_p = 220 Ω and Cp = 0.15 μF.

Using Varistors

Just as contact protection circuits are important to suppress noise while relay contacts are opening and closing, transient protection should be provided while the relays are open. This is the purpose of the varistor. When selecting a varistor, make certain that it has a voltage rating sufficient for your application. A typical 250 VAC varistor can be purchased with the Agilent part number 0873-0227.

Terminals and Connections Information

This section contains details about each of the terminals and connections available for the plug-in modules. Some modules have more than one available terminal. The table below shows the terminals available for each plug-in module. The general wiring information about each terminal is on the listed page number. Additionally, for some terminals, you will need to consult the specific plug-in module for connector pin-out diagrams and assignments.

Plug-in Module	Available Terminal(s)		Page
N2260A	N2290A N2296A N2297A N2299A	Screw Terminal Block Direct wiring (insulation displacement) connector DIN96 to twin D50 Cable DIN96 to quad D25 cable	277 278 279 281
N2261A	N2291A N2296A N2297A N2299A	Screw Terminal Block Direct wiring (insulation displacement) connector DIN96 to twin D50 Cable DIN96 to quad D25 cable	277 278 279 281
N2262A	N2292A N2296A N2298A	Screw Terminal Block Direct wiring (insulation displacement) connector DIN96 to D25 Cable	277 278 280
N2263A	N2293A N2296A N2297A N2299A	Screw Terminal Block Direct wiring (insulation displacement) connector DIN96 to twin D50 Cable DIN96 to quad D25 cable	277 278 279 281
N2264A	N2294A N2296A N2297A N2299A	Screw Terminal Block Direct wiring (insulation displacement) connector DIN96 to twin D50 Cable DIN96 to quad D25 cable	277 278 279 281
N2265A	N2295A N2296A N2297A N2299A	Screw Terminal Block Direct wiring (insulation displacement) connector DIN96 to twin D50 Cable DIN96 to quad D25 cable	277 278 279 281

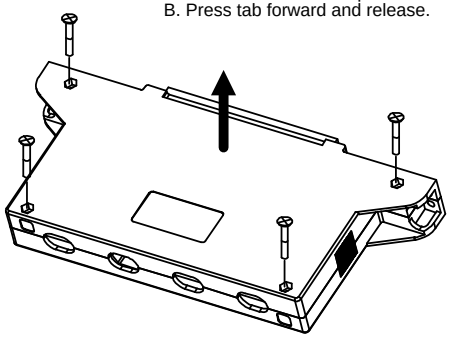
Plug-in Module	Available Terminal(s)		Page
N2266A	N2290A N2296A N2297A N2299A	Screw Terminal Block Direct wiring (insulation displacement) connector DIN96 to twin D50 Cable DIN96 to quad D25 cable	277 278 279 281
N2267A	N2327A	Crimp and Insert Kit	282
N2268A	Rear Panel	SMA Connectors	211
N2270A	N2320A	Crimp and Insert Kit	283
N2272A	Rear Panel	BNC Connectors	215
N2276A/B	Rear Panel	SMA Connectors (on switches or attenuators)	220
N2280A	Rear Panel	SC/APC Connectors	225
N2281A	Rear Panel	SC/APC Connectors	227
N2282A	Rear Panel	SC/APC Connectors	229
44470A	44480A	Screw Terminal Connector Block	285
44470D	44480B	Screw Terminal Block	287
44471A	44481A	Screw Terminal Connector Block	285
44471D	44481D	Screw Terminal Block	287
44472A	Rear Panel	BNC Connectors	244
44473A	44483A	Screw Terminal Connector Block	285
44474A	44484A	Screw Terminal Connector Block	285
44475A	44485A	Screw Terminal Connector Block	285
44476A/B	Rear Panel	SMA Connectors	259
44477A	44477A	Screw Terminal Connector Block	285
44478A/B	Rear Panel	BNC Connectors	270

N229X Screw Terminal Blocks

This terminal block is compatible with the N2290A, N2291A, N2292A, N2293A, and N2295A plug-in modules. Refer to each plug-in module section for detailed wiring information. The figure below shows the basic steps to wire and assemble this terminal block.

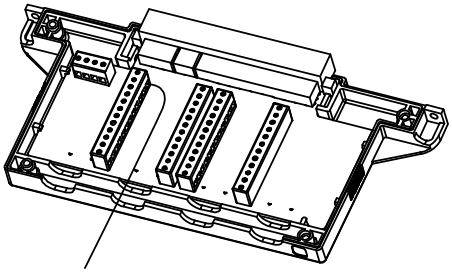
STEP 1. Remove cover

A. Release screws on top of the cover;
B. Press tab forward and release.



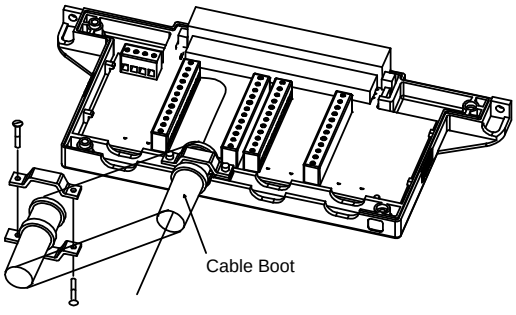
STEP 2. Attach wires

A. The wire gauge: 18-26 AWG;
B. Insert wire into terminal connectors;
C. Tighten screws on the connectors.



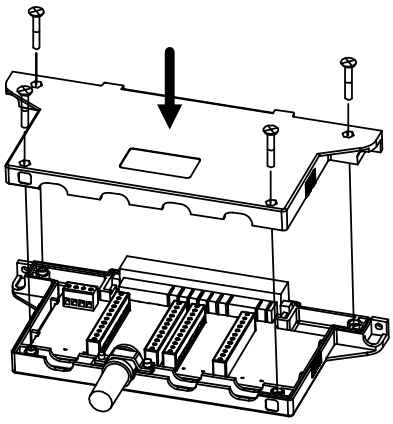
STEP 3. Tighten the wires

A. Insert the wires into the nearest cable boot, move the cable boot to the Cable slot;
B. Tighten the cable boot.



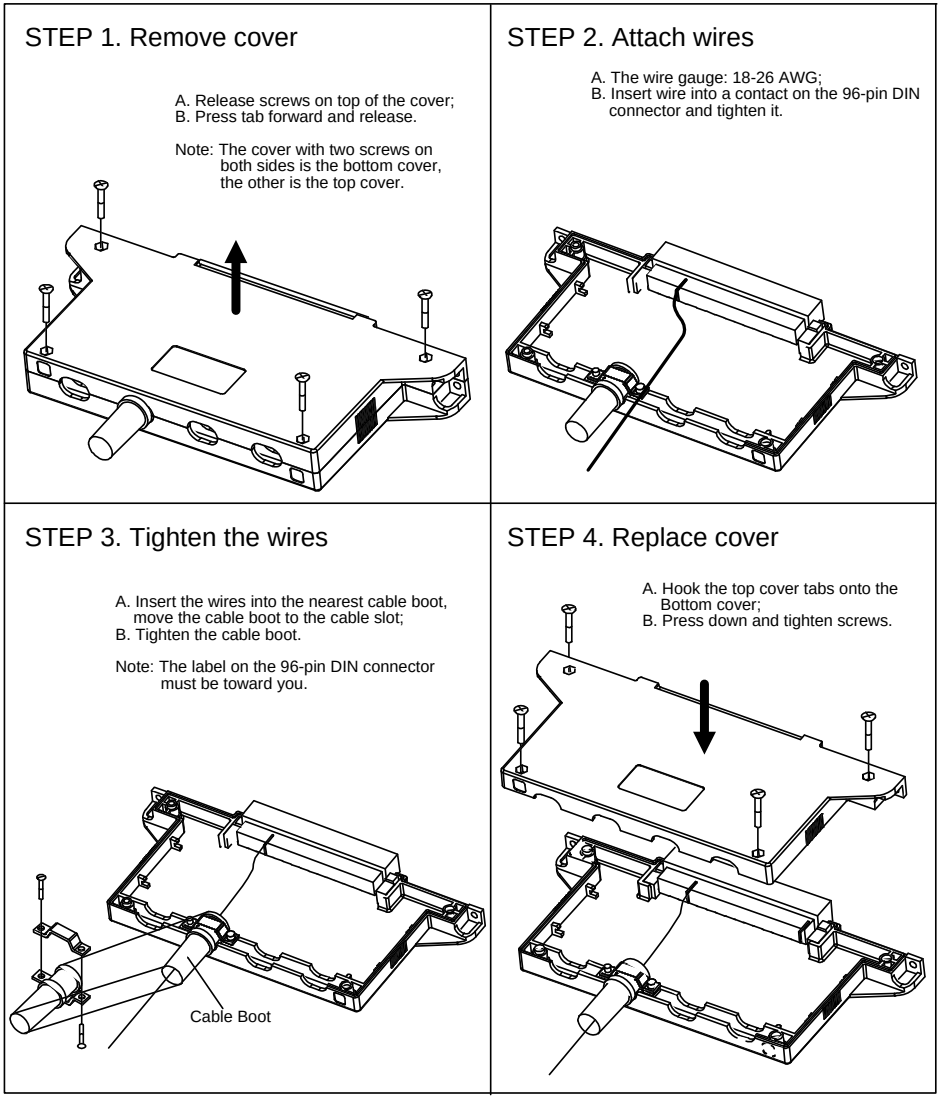
STEP 4. Replace cover

A. Hook the top cover tabs onto the fixture;
B. Press down and tighten screws.



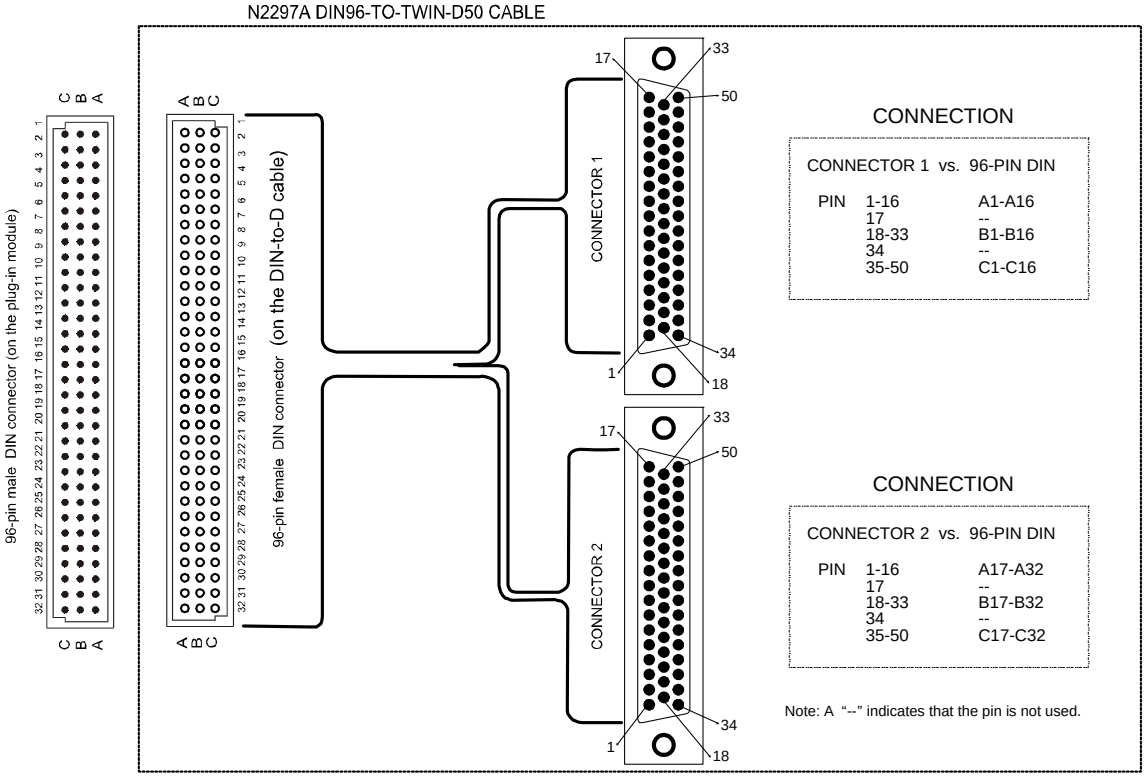
N2296A Insulation Displacement Connector

The N2296A is an insulation displacement connector you can use with the N2260A, N2261A, N2262A, N2263A, N2264A, and N2265A modules. The figure below shows the basic steps to wire and assemble this terminal. Refer to the specific plug-in module wiring information for details about the connector and pin-out assignments.


STEP 1. Remove cover
A. Release screws on top of the cover;
B. Press tab forward and release.
Note: The cover with two screws on both sides is the bottom cover, the other is the top cover.
STEP 2. Attach wires
A. The wire gauge: 18-26 AWG;
B. Insert wire into a contact on the 96-pin DIN connector and tighten it.
STEP 3. Tighten the wires
A. Insert the wires into the nearest cable boot, move the cable boot to the cable slot;
B. Tighten the cable boot.
Note: The label on the 96-pin DIN connector must be toward you.
Cable Boot
STEP 4. Replace cover
A. Hook the top cover tabs onto the Bottom cover;
B. Press down and tighten screws.

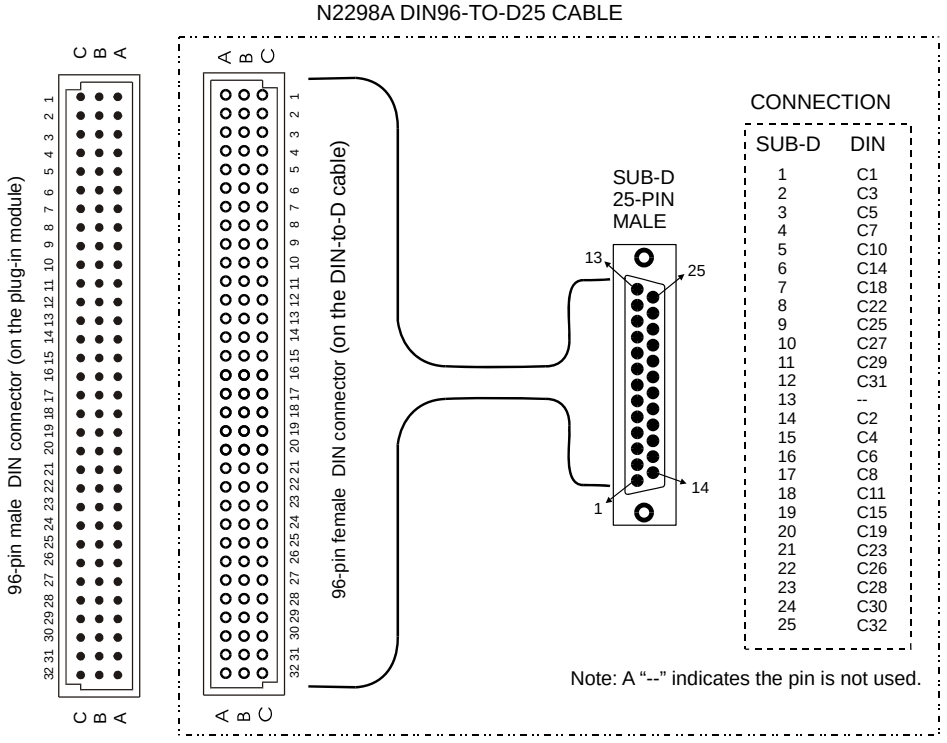
N2297A DIN96 to twin D50 Cable

The N2297A is a female DIN96 to twin male D50 Cable. The cable uses 26 AWG wire (which meets UL AWM: 2464) with overall foil shield. The maximum voltage is 200 volts per wire. The figure below shows the connections between the D96 and the two D50s. Refer to the specific plug-in module wiring information for details about the connector and pin-out assignments.



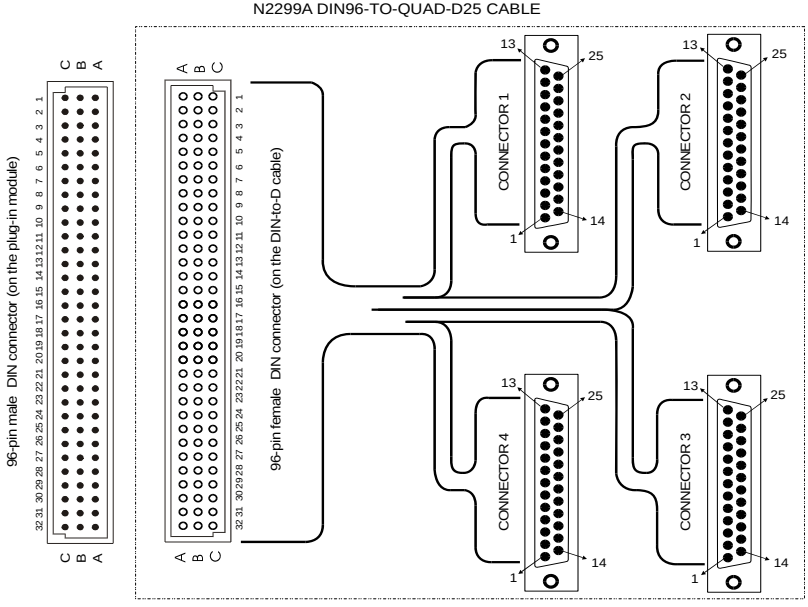
N2298A DIN96 to D25 Cable

The N2298A is a female DIN96 to a male Sub-D25 Cable. The cable uses 26 AWG wire (which meets UL AWM: 2464) with overall foil shield. The maximum voltage is 200 volts per wire. The figure below shows the connections between the D96 and the Sub-D250. Refer to the N2262A module wiring information (page 186) for details about the connector and pin-out assignments.



N2299A DIN96 to quad D25 Cable

The N2297A is a female DIN96 to four male D25 Cable. The cable uses 26 AWG wire (which meets UL AWM: 2464) with overall foil shield. The maximum voltage is 200 volts per wire. The figure below shows the connections between the D96 and the four D25s. Refer to the specific plug-in module wiring information for details about the connector and pin-out assignments.



CONNECTOR 1 vs. 96-PIN DIN

SUB-D	DIN
1	A1
2	B1
3	C1
4	A3
5	B3
6	C3
7	A5
8	B5
9	C5
10	A7
11	B7
12	C7
13	--
14	A2
15	B2
16	C2
17	A4
18	B4
19	C4
20	A6
21	B6
22	C6
23	A8
24	B8
25	C8

CONNECTOR 2 vs. 96-PIN DIN

SUB-D	DIN
1	A9
2	B9
3	C9
4	A11
5	B11
6	C11
7	A13
8	B13
9	C13
10	A15
11	B15
12	C15
13	--
14	A10
15	B10
16	C10
17	A12
18	B12
19	C12
20	A14
21	B14
22	C14
23	A16
24	B16
25	C16

CONNECTOR 3 vs. 96-PIN DIN

SUB-D	DIN
1	A17
2	B17
3	C17
4	A19
5	B19
6	C19
7	A21
8	B21
9	C21
10	A23
11	B23
12	C23
13	--
14	A18
15	B18
16	C18
17	A20
18	B20
19	C20
20	A22
21	B22
22	C22
23	A24
24	B24
25	C24

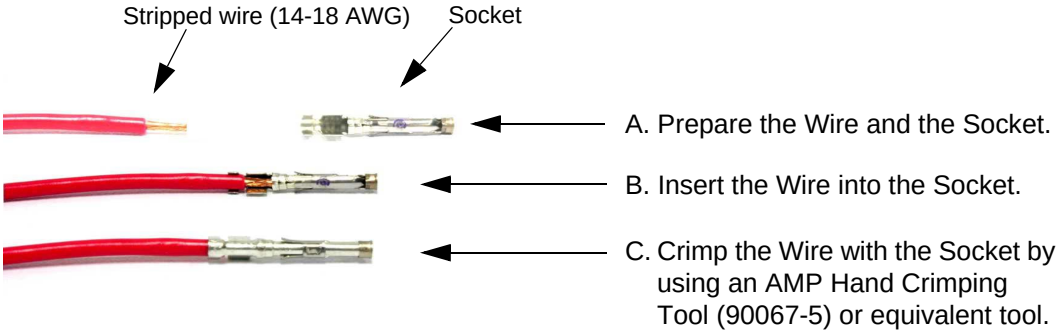
CONNECTOR 4 vs. 96-PIN DIN

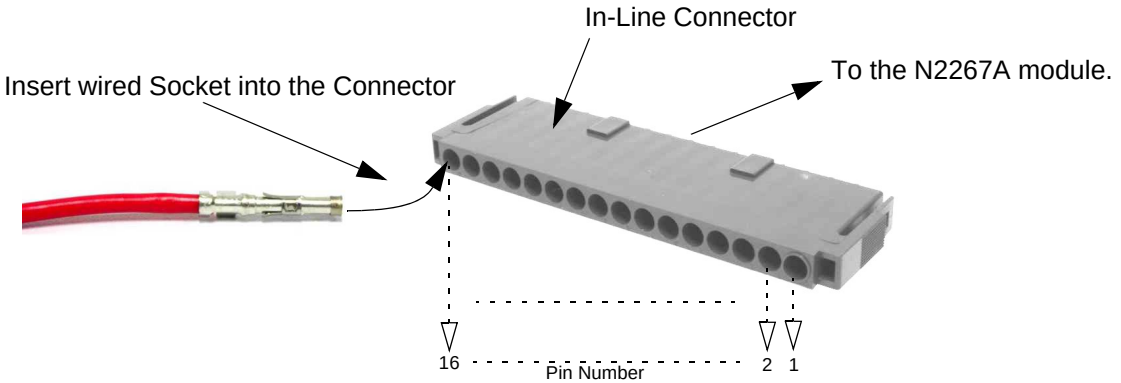
SUB-D	DIN
1	A25
2	B25
3	C25
4	A27
5	B27
6	C27
7	A29
8	B29
9	C29
10	A31
11	B31
12	C31
13	--
14	A26
15	B26
16	C26
17	A28
18	B28
19	C28
20	A30
21	B30
22	C30
23	A32
24	B32
25	C32

Note: A "--" indicates the pin is not used.

N2327A Crimp and Insert Terminal Block

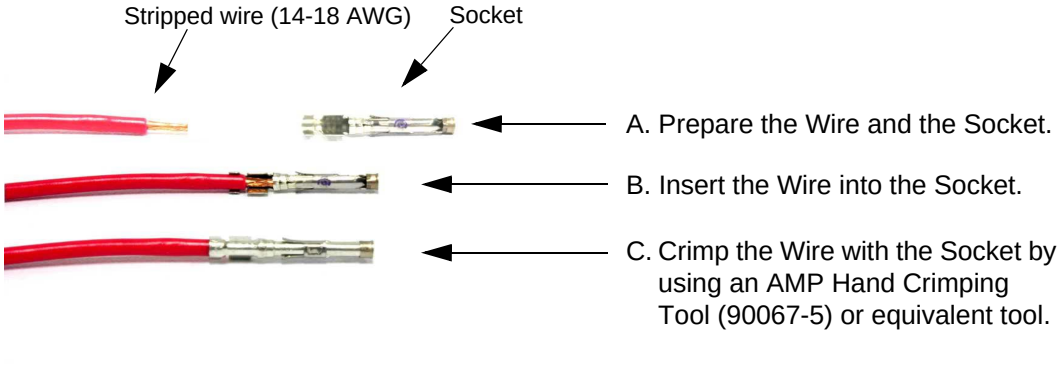
This terminal is for the N2267A plug-in module only. Refer to the N2267A module wiring information (page 208) for details about the connector and pin-out assignments. The figures below illustrate how to wire and assemble this terminal.

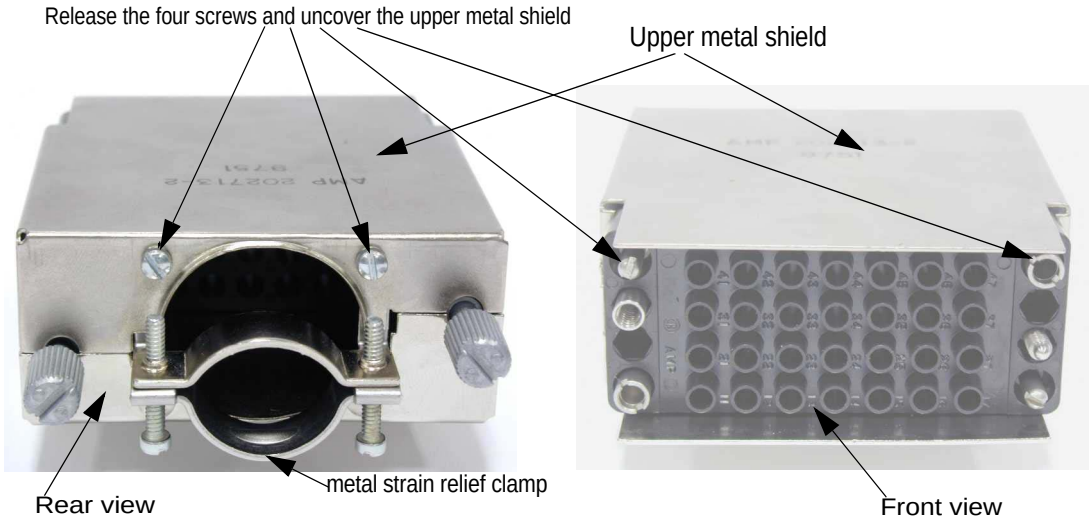

Stripped wire (14-18 AWG)
Socket
A. Prepare the Wire and the Socket.
B. Insert the Wire into the Socket.
C. Crimp the Wire with the Socket by using an AMP Hand Crimping Tool (90067-5) or equivalent tool.

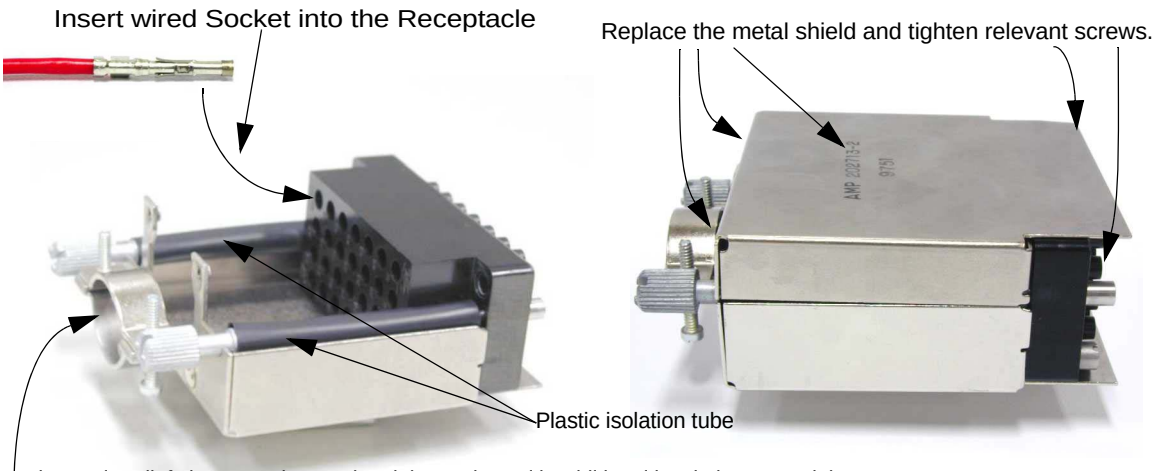


N2320A Crimp and Insert Terminal Block

This terminal block is for the N2270A plug-in module only. Refer to the N2270A module wiring information (page 213) for details about the connector and pin-out assignments. The figures below illustrate how to wire and assemble this terminal.


Stripped wire (14-18 AWG)
Socket
A. Prepare the Wire and the Socket.
B. Insert the Wire into the Socket.
C. Crimp the Wire with the Socket by using an AMP Hand Crimping Tool (90067-5) or equivalent tool.

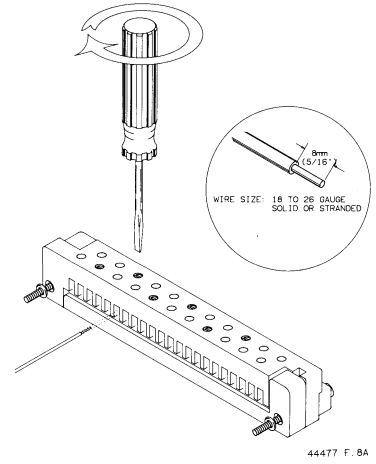

Release the four screws and uncover the upper metal shield
Upper metal shield
metal strain relief clamp
Rear view
Front view



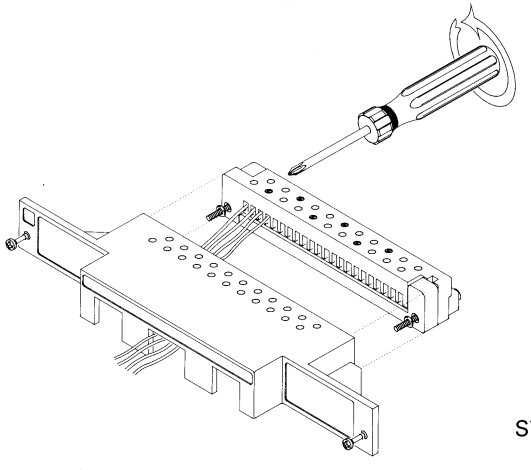
The strain relief clamp can be used to tighten wires with additional insulation around them. Additional insulation should be used around the wires to prevent possible damage caused by the strain relief clamp.

4448X Screw Terminal Connector Blocks

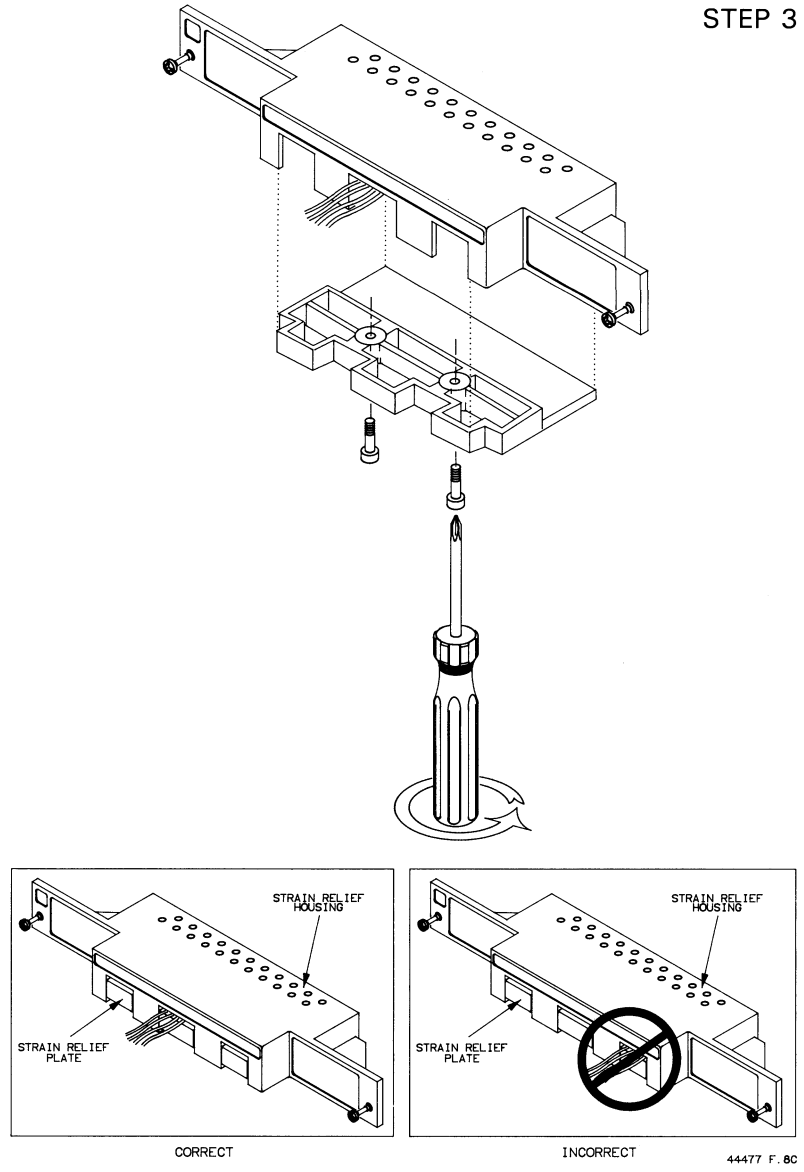
Screw terminal connectors are available for the 44470A, 44471A, 44473A, 44474A, 44475A, and 44477A plug-in modules. One of these terminals is shipped with each plug-in module. Refer to the specific plug-in module wiring information for details about the connector and pin-out assignments. The figures below shows the basic steps to wire and assemble this type of terminal.



STEP 1

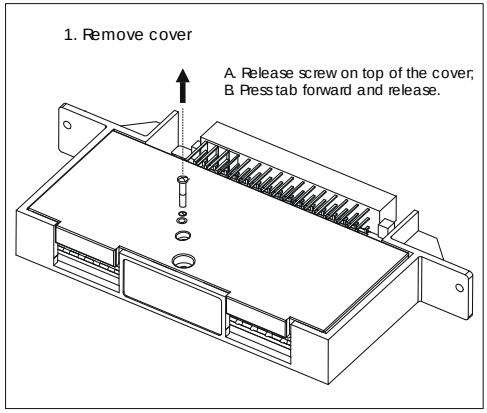


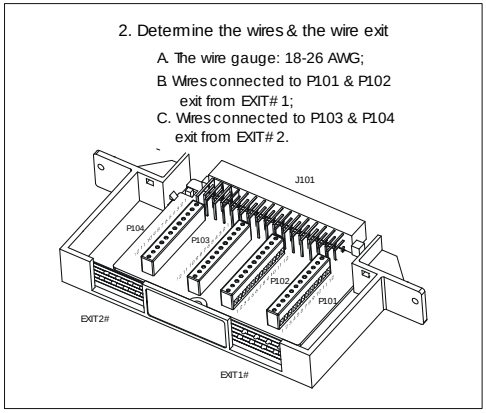
STEP 2

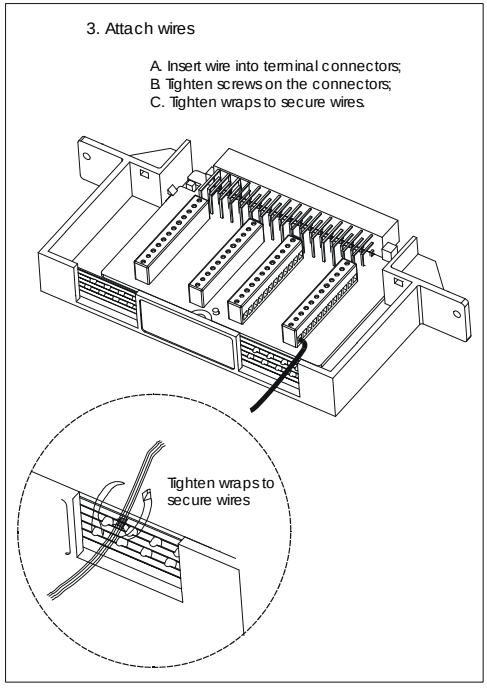

STEP 3
STRAIN RELIEF HOUSING
STRAIN RELIEF PLATE
CORRECT
STRAIN RELIEF HOUSING
STRAIN RELIEF PLATE
INCORRECT
44477 F.8C

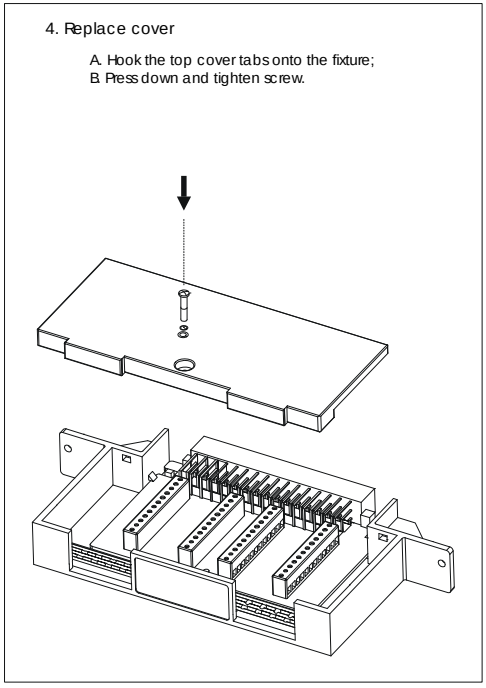
4448x Screw Terminal Blocks

Screw terminal blocks are available for the 44470D and 44471D plug-in modules. One of these terminals is shipped with each plug-in module. Refer to the specific plug-in module wiring information for details about the terminal block. The figures below shows the basic steps to wire and assemble this type of terminal.






3. Attach wires
A. Insert wire into terminal connectors;
B. Tighten screws on the connectors;
C. Tighten wraps to secure wires.
Tighten wraps to secure wires



Application Programs

Application Programs

This chapter provides example programs in Visual C++, Visual BASIC and BASIC to help you develop programs for your specific application. Chapter contents include:

- Visual C++ Example Program, on page 291
- Visual BASIC Example Program, on page 293
- VB.net Example Program, on page 296
- BASIC Example Program, on page 298

Note

For the example programs provided in this chapter to run properly, make sure that your system has been properly setup according to the requirements of the individual example.

Visual C++ Example Program

This example program is written in Visual C++ 6.0 and has been tested on a PC running WIN95/NT. The example uses the SCPI commands. As the example is currently written, the program requirements are:

- GPIB interface selected and set to the address of 09 from the front-panel;
- Any one of the relay modules installed in Slot 1 of the mainframe;
- A GPIB interface card installed in your PC with the VISA library.

To program a 3499A/B/C using the RS-232 interface, you will need to modify the code at the top of the program. Change the line **`# define USING_RS232 0`** to **`# define USING_RS232 1`**. On the 3499A/B/C, select the RS-232 interface and set its parameters to: BAUD RATE (9600), PARITY (NONE, 8 BITS), and FLOW (FLOW NONE). A GPIB card in your PC is not necessary if you are using RS-232.

```
# include <stdio.h>
# include <windows.h>
# include "visa.h"

# define USING_RS232 0          // Change 0 to 1 if RS-232 interface
                                // is to be used.

# if USING_RS232
# define INST_ADDR"ASRL1::INSTR"// 3499A/B/C RS-232 address.
# else
# define INST_ADDR"GPIB0::9::INSTR"// 3499A/B/C GPIB address.
# endif

void main()
{
    ViSession drm;              // Session to default resource manager.
    ViSession vi;               // Session to instrument.
    ViStatus status;            // VISA function status return code.
    char retStr[128];           // String returned from the instrument.

    /* Open the default resource manager. */
    status = viOpenDefaultRM( &drm );
    if ( status < VI_SUCCESS ) {
        printf( "VISA ERROR: viOpenDefaultRM()\n");
        exit(1);
    }

    /* Open a session to the 3499A/B/C. */
    status = viOpen( drm, INST_ADDR, VI_NULL, VI_NULL, &vi );
    if ( status < VI_SUCCESS ) {
        printf( "VISA ERROR: viOpen(). Address: %s\n",INST_ADDR);
        viClose( drm );
        exit(1);
    }
```

```
    # if USING_RS232
    /* Set RS-232 parameters according to 3499A/B/C settings:
       BAUD RATE (9600), */
    /* PARITY (NONE, 8 BITS), FLOW (FLOW NONE). */
    viSetAttribute( vi, VI_ATTR_ASRL_BAUD, 9600 );
    viSetAttribute( vi, VI_ATTR_ASRL_DATA_BITS, 8 );
    viSetAttribute( vi, VI_ATTR_ASRL_FLOW_CNTRL, VI_ASRL_FLOW_NONE );
    viSetAttribute( vi, VI_ATTR_ASRL_PARITY, VI_ASRL_PAR_NONE );
    # endif

    /* Set 3499A/B/C to SCPI mode. */
    viPrintf( vi, "SYSMODE SCPI\n" );
    Sleep(4000);// Wait 4 seconds.

    /* Reset the instrument to a known state. */
    viPrintf( vi, "*RST\n" );
    Sleep( 4000 );

    /* Close channels 100 through 103.
    viPrintf( vi, "CLOSE (@ 100:103)\n" );

    /* Open channels 100 through 103. */
    viPrintf( vi, "OPEN (@ 100:103)\n" );

    /* Scanning setup: executing the following commands to make
       the instrument to scan sweep */
    /* channels 100 through 103 two times. The channels are scanned
       continuously and the second scan sweep starts 1 second after
       the start of the first scan sweep. */
    viPrintf( vi, "SCAN (@ 100:103)\n" );// Create a scan list.
    viPrintf( vi, "ARM:SOURCE TIMER\n" );// Set arm source to TIMER.
    viPrintf( vi, "ARM:TIMER 1\n" );// Interval time between two scan
                                    // sweeps is 1 second.
    viPrintf( vi, "ARM:COUNT 2\n" );// Set scan sweep 2 times.
    viPrintf( vi, "TRIG:SOURCE IMM\n" );// Set trigger source to
                                        // IMM (default).
    viPrintf( vi, "CHAN:DELAY 0, ( @100:103)\n");// Set channel delay
                                                 //time to 0 (default).
    viPrintf( vi, "INIT\n");// Start the scan.

    /* Set visa time-out value to 10 seconds. */
    viSetAttribute( vi, VI_ATTR_TMO_VALUE, 10000 );

    /* *OPC command will wait until scan finishes. */
    status = viQueryf( vi, "*OPC?\n","%t*", retStr );
    printf("Scan End.\n");

    viClose( vi );// Close session to 3499A/B/C.
    viClose( drm );// Close session to the resource manager.
}
```

Visual BASIC Example Program

This example program is written in Visual BASIC 6.0 and has been tested on a PC running WIN95/NT. The example uses the SCPI commands. As the example is currently written, the program requirements are:

- GPIB interface selected and set to the address of 09 from the front-panel;
- Any one of the relay modules installed in Slot 1 of the mainframe;
- A GPIB interface card installed in your PC with the VISA library.

To program a 3499A/B/C using the RS-232 interface, you will need to modify the code at the top of the program. Change the line **`Const USING_RS232 =0`** to **`Const USING_RS232 =1`**.
On the 3499A/B/C, select the RS-232 interface and set its parameters to: BAUD RATE (9600), PARITY (NONE, 8 BITS), and FLOW (FLOW NONE). A GPIB card in your PC is not necessary if you are using RS-232.

```
Const USING_RS232 =0' Change 0 to 1 if RS-232 interface is to be used.
    ' Sleep( ) function declaration.
Declare Sub Sleep Lib "Kernel32" (ByVal s As Long)

Sub main()

    Dim drm As Long            ' Session to default resource manager.
    Dim vi As Long             ' Session to instrument.
    Dim status As Long         ' VISA function status return code
    Dim retStr As String * 128 ' String returned from the instrument.
    Dim str As String          ' String for individual channel number.

    On Error GoTo ErrorHandler

    ' Open default resource manager.
    drm = -1
    status = viOpenDefaultRM(drm)
    If (status < VI_SUCCESS) Then GoTo VisaErrorHandler

    ' Select an interface for 3499A/B/C.
    ' GPIB interface is used when USING_RS232 = 0,
    ' or RS-232 interface is used when USING_RS232 = 1.
    If USING_RS232 Then
        INST_ADDR = "ASRL1::INSTR"
    Else
        INST_ADDR = "GPIB0::9::INSTR"
    Endif

    ' Open a session to 3499A/B/C.
    status = viOpen(drm, INST_ADDR, 0, 0, vi)
    If (status < VI_SUCCESS) Then GoTo VisaErrorHandler
```

```
    ' Set RS-232 interface parameters when USING_RS232 equals 1.
    If USING_RS232 Then
        Call viSetAttribute(vi, VI_ATTR_ASRL_BAUD, 9600)
        Call viSetAttribute(vi, VI_ATTR_ASRL_DATA_BITS, 8)
        Call viSetAttribute(vi, VI_ATTR_ASRL_STOP_BITS,_
VI_ASRL_STOP_ONE)
        Call viSetAttribute(vi, VI_ATTR_ASRL_FLOW_CNTRL,_
VI_ASRL_FLOW_NONE)
        Call viSetAttribute(vi, VI_ATTR_ASRL_PARITY, VI_ASRL_PAR_NONE)
    End If

    ' Set the 3499A/B/C to SCPI mode.
    Call viVPrintf(vi, "SYSMODE SCPI" + Chr$(10), 0)
    Call Sleep(4000)    ' Wait 4 seconds

    ' Reset the instrument to a known state.
    Call viVPrintf(vi, "*RST" + Chr$(10), 0)
    Call Sleep(4000)

    ' Close channels 100 through 103.
    Call viVPrintf(vi, "CLOSE ( @ 100:103)" + Chr$(10), 0)

    ' Open channels 100 through 103.
    Call viVPrintf(vi, "OPEN ( @ 100:103)" + Chr$(10), 0)

    ' Scanning setup: the following commands make the instrument scan
    ' channels 100 through 103 two times. The channels are scanned
    ' continuously and the second scan sweep starts 1 second after the
    ' start of the first scan sweep.

' Create a scan list 100 through 103.
    Call viVPrintf(vi, "SCAN (@100:103)" + Chr$(10), 0)
' Set arm source to TIMER.
    Call viVPrintf(vi, "ARM:SOURCE TIMER" + Chr$(10), 0)
' Interval time between two scan sweeps is 1 second.
    Call viVPrintf(vi, "ARM:TIMER 1" + Chr$(10), 0)
' Set scan sweep two times.
    Call viVPrintf(vi, "ARM:COUNT 2" + Chr$(10), 0)
' Set trigger source to IMM (default).
    Call viVPrintf(vi, "TRIG:SOURCE IMM" + Chr$(10), 0)
' Set trigger source to IMM (default).
    Call viVPrintf(vi, "CHAN:DELAY 0, (@100:103)" + Chr$(10), 0
' Start scanning.
    Call viVPrintf(vi, "INIT" + Chr$(10), 0)

' Set visa time-out value to 10 seconds
    Call viSetAttribute(vi, VI_ATTR_TMO_VALUE, 10 * 1000)

' *OPC command will wait until scan finished.
    Call viVQueryf(vi, "*OPC?" + Chr$(10), "%t*", retStr)

    viClose (vi)' Close session to 3499A/B/C.
    viClose (drm)' Close session to default resource manager.
    End
```

```
ErrorHandler:
    ' Display the error message.
    MsgBox "*** Error : " + Error$, MB_ICON_EXCLAMATION
    If drm <> -1 Then
        viClose (drm)
    End If
    End

VisaErrorHandler:
    Dim strVisaErr As String * 200
    Call viStatusDesc(defrm, status, strVisaErr)
    MsgBox "*** Error : " + strVisaErr
    If drm <> -1 Then
        viClose (drm)
    End If
    End
End Sub
```

VB.net Example Program

This example is written in VB.net. The example includes Open, Close, Self-test, Digital I/O, and Scan commands for the 3499A/B/C using the Agilent T&M Toolkit in VB.net (Visual Basic). As the example is currently written, the program requirements are:

- GPIB interface selected and set to the address of 09 from the front-panel;
- A GPIB interface card installed in your PC with the VISA library;
- An Agilent N2265A installed in Slot 1 of the mainframe;
- The Agilent T&M Toolkit installed on your PC.

```
Imports Agilent.TMFramework
Imports Agilent.TMFramework.InstrumentIO

Public Class Form1
    Inherits System.Windows.Forms.Form

#Region " Windows Form Designer generated code "
    Private myDirectIO As DirectIO
    Private Sub Form1_Load(ByVal sender As System.Object, _
ByVal e As System.EventArgs) Handles MyBase.Load
        'Create DirectIO object.
        myDirectIO = New DirectIO("GPIB0::9::INSTR", False, 2000)
        myDirectIO.Timeout = 2000

    End Sub

    Private Sub Selftestbtn_Click(ByVal sender As System.Object, _
ByVal e As System.EventArgs) Handles Selftestbtn.Click
        'Send *TST (Selftest) command to the 3499.
        myDirectIO.WriteLine("*tst?")


        Timing.Delay(10000000)


        'Read results
        Dim Results As String
        Results = myDirectIO.Read()
        Textbox1.Text = Results

    End Sub

    Private Sub Results_TextChanged(ByVal sender As System.Object, _
ByVal e As System.EventArgs) Handles Textbox1.TextChanged

    End Sub
```

```
    'This example closes/opens multiple switches within a 4x4 Matrix.
    'The switches can be controlled within one command line or listed
   'separtely.
    Private Sub Closebtn_Click(ByVal sender As System.Object, _
ByVal e As System.EventArgs) Handles Closebtn.Click
        myDirectIO.WriteLine("CLOS (@120,123)")
    End Sub

    Private Sub Openbtn_Click(ByVal sender As System.Object, _
ByVal e As System.EventArgs) Handles Openbtn.Click
        myDirectIO.WriteLine("OPEn (@120)")
        myDirectIO.WriteLine("OPEn (@123)")
    End Sub



    'Digital Input/Output - on power up or after Reset all Digital I/O
    'ports in the 3499 will be input ports. Mode 1 is default mode.
    Private Sub DigIObtn_Click(ByVal sender As System.Object, _
ByVal e As System.EventArgs) Handles DigIObtn.Click
        myDirectIO.WriteLine("SENSE:DIGITAL:DATA:BYTE:VALue? 140")


       'Read the Digital Input results 8 bits (1 byte), binary value is
      'displayed.
        Dim Digitalin As String
        Digitalin = myDirectIO.Read()
        TextBox2.Text = Digitalin
    End Sub
    'Create and execute a scan list
    Private Sub Scanbtn_Click(ByVal sender As System.Object, _
ByVal e As System.EventArgs) Handles Scanbtn.Click
        myDirectIO.WriteLine("SCAN (@200:209,220:225)")
        myDirectIO.WriteLine("INIT")
        myDirectIO.WriteLine("SCAN:LIST?")

        Dim Scanresults As String
        Scanresults = myDirectIO.Read()
        Scanlst.Text = Scanresults
    End Sub

End Class
```

BASIC Example Program

Sample programs in this section are written in BASIC 6.0 and have been tested on a UNIX workstation.

Requirements:

- GPIB interface selected and set to the address of 09 from the front-panel;
- Any one of the relay modules installed in Slot 1 of the mainframe;
- A GPIB interface card installed in your UNIX workstation.

Note Either GPIB or RS-232 interface can be used in SCPI mode. However, we only provide and test the BASIC program examples over the GPIB interface.

```
10  ! EXAMPLE.BAS: TEST 3499A/B/C IN SCPI MODE
20  DIM Retstr$[128]! String returned from the instrument.
30  OUTPUT 709; "SYSMODE SCPI"! Set 3499A/B/C to SCPI mode.
40  WAIT 4! Wait 4 seconds.
50  OUTPUT 709; "*RST"! Reset 3499A/B/C.
60  WAIT 4! Wait 4 second.
70  OUTPUT 709; "CLOSE (@100:103)"! Close channels 100 through 103.
80  OUTPUT 709; "OPEN (@100:103)"! Open channels 100 through 103.

100 ! LINES 150 TO 200 SET UP A TIMER CONTROLLED SCANNING.
110 ! 3499A/B/C SCAN SWEEP CHANNELS 100 THROUGH 139 TWO TIMES.
120 ! THE CHANNELS ARE SCANNED CONTINUOUSLY.
130 ! THE SECOND SCAN SWEEP STARTS 1 SECOND AFTER THE START
140 ! OF THE FIRST SCAN SWEEP.
150 OUTPUT 709; "SCAN (@100:103)"! Create a scan list.
160 OUTPUT 709; "ARM:SOUR TIMER"! Set arm source to timer.
170 OUTPUT 709; "ARM:TIMER 1"! Interval time between two scan sweeps
                          ! is 1 second.
180 OUTPUT 709; "ARM:COUNT 2"! Set scan sweep 2 times.
190 OUTPUT 709; "TRIG:SOUR IMM"! Set trigger source to IMM (default).
200 OUTPUT 709; "CHAN:DELAY 0, (@100:103)"! Set channel delay time
                                           !to 0 (default).
210 OUTPUT 709; "INIT"! Start scanning
220 OUTPUT 709; "*OPC?"! Wait until scan finishes.
230 ENTER 709; Retstr$
240 Done: END
```

Specifications

Specifications

Specification for the mainframe and all plug-in modules are given in this chapter for easy reference. This chapter includes:

- 3499A/B/C Mainframe, on page 301
- N2260A 40-Channel MUX Module, on page 303
- N2261A 40-Channel GP Relay Module, on page 305
- N2262A 4 x 8 2-Wire Matrix Switch Module, on page 307
- N2263A 32-bit Digital I/O Module, on page 309
- N2264A Multifunction Module, on page 310
- N2265A Multifunction Module, on page 313
- N2266A 40-Channel MUX Module, on page 315
- N2267A 8-Channel High Current GP Module, on page 317
- N2268A 50Ω 3.0 GHz Dual 1-to-4 MUX Module, on page 319
- N2270A 10-Channel High Voltage MUX Module, on page 321
- N2272A 1 GHz RF 1-to-9 MUX Module, on page 323
- N2276A Dual 1-to-6(4) Microwave MUX/Attenuator Module, on page 325
- N2276B Microwave MUX/Attenuator Module, on page 325
- N2280A Quadruple 1-to-2 Optical Switch Module, on page 326
- N2281A Dual 1-to-4 Optical Switch Module, on page 327
- N2282A 1-to-8 Optical Switch Module, on page 328
- 44470A 10-Channel MUX Module, on page 329
- 44470D 20-Channel MUX Module, on page 331
- 44471A 10-Channel GP Relay Module, on page 333
- 44471D 20-Channel GP Relay Module, on page 335
- 44472A Dual 4-Channel VHF Switch Module, on page 337
- 44473A 4 x 4 2-Wire Matrix Switch Module, on page 339
- 44474A 16-Bit Digital I/O Module, on page 341
- 44475A Breadboard Module, on page 342
- 44476A Microwave Switch Module, on page 344
- 44476B Microwave Switch Module, on page 344
- 44477A Form-C Relay Module, on page 345
- 44478A/B 1.3 GHz Dual 4-to-1 MUX Modules, on page 347

3499A/B/C Mainframe

■ GENERAL	
Power Supply:	For 3499A/B: ~100 to 127 Vac, 50Hz to 400 Hz ~200 to 240 Vac, 50Hz to 60 Hz 90 VA maximum; For 3499C: ~100 to 240 Vac, 50Hz to 60 Hz; 140 VA maximum.
Operating Environment:	0 to 55^{o}C (32 to 131^{o}F); < 80% RH, 0 to 40^{o}C (32 to 104^{o}F).
Storage Environment:	-40 to +70^{o}C (-40 to 158^{o}F).
Net Weight:	3499A: 3.8 kg (8.4 lbs); 3499B: 2.5 kg (5.5 lbs); 3499C: 7.4 kg (16.4 lbs).
Dimensions:	3499A (H x W x L): 89mm x 426mm x 348mm (3.5” x 16.8” x 13.7”); 3499B (H x W x L): 89mm x 213mm x 348mm (3.5” x 8.4” x 13.7”); 3499C (H x W x L):221.5mm x 426mm x 353.5mm (8.7” x 16.8“ x 13.9”).
Operating Altitude	3000 meters (10,000 ft)
IEC 61010-1 Operating Polution Degree	2
IEC61010-1 Installation Category	II
■ SYSTEM	
Capacity:	3499A: 5 slots; 3499B: 2 slots; 3499C: electrically 9 slots (Slot 1~6 are 1-slot width, Slot 7 is 2-slot width, Slot 8~9 are 3-slot width).
Display:	Vacuum fluorescent, 13 characters can be displayed simultaneously.
Rear Panel Connectors:	GPIB (IEEE 488); RS-232; 8-pin Mini DIN connector (built-in 4-bit Digital I/O & built-in external trigger in/out).
Memory:	For 3499A/B mainframe with Controller board 1.0 (Firmware REV 1.0/2.0/3.0): Capable of storing 10 instrument setups and 10 errors in SCPI mode or 40 instrument setups and 1 error in 3488A mode. For 3499A/B/C mainframe with Controller board 2.0 (Firmware REV 4.0 or later): Capable of storing 50 instrument setups and 10 errors in SCPI mode or 40 instrument setups and 1 error in 3488A mode.

■ SYSTEM (continued)	
Switch Setting Time:	Automatically selected by the mainframe for individual modules; Additional time from 0 to 99999.999 seconds can be added in 1 ms steps.
Arm Source:	External trigger (from the rear panel Mini DIN connector); IEEE-488 bus (GET, *TRG, or pressing **Step** from the front-panel); Software (TRIGger:IMM); Internal timer (programmable as 0 to 99999.999 seconds in 1 ms steps).
Trigger Source:	External trigger (from the rear panel Mini DIN connector); IEEE-488 bus (GET, *TRG, or pressing **Step** from the front-panel); Software (Trigger:IMM); Internal timer (programmable as 0 to 99999.999 seconds in 1 ms steps).
External Trigger Input:	Level: TTL compatible; Minimum trigger pulse width: 2 μs; Maximum external trigger delay[a]: 2 ms.
External Trigger Output:	Level: Normally pull up to 5 V; Sink current: 10 mA @ V_o(Low) ≤ 0.4V; 80 mA @ V_o(Low) ≤ 0.8V; Low going pulse width: 10 μs typical.
Built-in 4-bit Digital I/O:	Input: TTL compatible; Output: V_o(high) ≥ 2.4V @ I_o = 1 mA; V_o(Low) ≤ 0.8V @ I_o = –100 mA; Maximum V_o = 42V, with external pull-up.

■ SYSTEM SPEED[b]			
Scan Speed:	350 chans/sec (N2266A)		
Parser Time[c]:	Open (@100): 3 ms Close (@100): 3 ms Open (@100:139): 4 ms		
Switching Speed:		Channels	Time (ms)
	Open/Close:	1	7.1 (N2266A)
	Open/Close:	10	22.0 (N2266A, in the same group)
	Open/Close:	40	28.9 (N2266A)
Digital I/O Block Transfer Rate:	20K bytes/sec (long word)		

a. Maximum time from activation of external trigger pulse to start of switch open or close.
b. The system speed specification may vary in a small range due to the speed of the remote PC, the GPIB module, the version of VISA and the version of 3499A/B/C's firmware used.
c. Measured from the time at which the command terminator is taken from the bus to the time at which the relay begins to open or close.

N2260A 40-Channel MUX Module

■ INPUT CHARACTERISTICS

Total Channels:	80 1-wire; or 40 2-wire; or dual 20 2-wire; or 20 4-wire	
Maximum Voltage:	Terminal-Terminal or Terminal-Chassis:	200 V, dc or ac rms
Maximum Current:	Per Channel:	1 A, dc or ac rms
	Per Module:	2A, dc or ac rms
Maximum Power:	Per Channel:	60 W dc; 62.5 VA ac
	Per Module:	120 W dc; 125 VA ac
Thermal Offset:	< 3 μV differential or single-ended	
Initial Closed Channel Resistance:	< 1 Ω	
Relay Life:	Mechanical: Electrical:	10^8 (at 36000 operations/hour) 5×10^5 (1A load)
Maximum Scan Rate:	80 Chans/sec	

■ DC ISOLATION (with terminal block)

Open Channel, Channel-Channel: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω
HI-LO: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω
Channel-Chassis: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω

■ AC ISOLATION / PERFORMANCE[a] (without terminal block)

Capacitance: (with 1 channel closed)	Open Channel, Channel-Channel:	< 7 pF (2-wire);	< 7 pF (dual 2-wire)
	HI-LO:	< 75 pF (2-wire);	< 45 pF (dual 2-wire)
	Channel-Chassis:	< 150 pF (2-wire);	< 90 pF (dual 2-wire)
Insertion Loss: (with 50Ω termination)	100 kHz:	< 0.10 dB	
	1 MHz:	< 0.20 dB	
	10 MHz:	< 1.50 dB	
Crosstalk: (with 50Ω termination)	100 kHz:	< -70 dB (2-wire);	< -40 dB (1-wire)
	1 MHz:	< -50 dB (2-wire);	< -25 dB (1-wire)
	10 MHz:	< -30 dB (2-wire);	NA (1-wire)

a. With chassis of all instruments connected, and with the Lo Terminal of the input connected to the Lo Terminal of the output (either directly or via the 3499A/B/C switching channels).

N2261A 40-Channel GP Relay Module

■ INPUT CHARACTERISTICS

Total Channels:	40	
Maximum Voltage:	Terminal-Terminal or Terminal-Chassis:	200 V, dc or ac rms
Maximum Current:	Per Channel: Per Module:	1 A, dc or ac rms 20 A, dc or ac rms
Maximum Power:	Per Channel: Per Module:	60 W dc; 62.5 VA ac 1200 W dc; 1250 VA ac
Thermal Offset:	Per Channel:	< 3 μV
Initial Closed Channel Resistance:	< 0.5 Ω	
Relay Life:	Mechanical: Electrical:	10^8 (at 36000 operations/hour) 5×10^5 (1A load)
Maximum Scan Rate:	80 Chans/sec	

■ DC ISOLATION (with terminal block)

Open Channel, Channel-Channel: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω
Channel-Chassis: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω

■ AC ISOLATION / PERFORMANCE[a] (without terminal block)

Capacitance: (with 1 channel closed)	Open Channel, Channel-Channel:	< 10 pF
	Channel-Chassis:	< 20 pF
Insertion Loss: (with 50Ω termination)	100 kHz:	< 0.10 dB
	1 MHz:	< 0.20 dB
	10 MHz:	< 0.50 dB
Crosstalk: (with 50Ω termination)	100 kHz:	< -70 dB
	1 MHz:	< -50 dB
	10 MHz:	< -30 dB

a. With chassis of all instruments connected, and with Low Terminal of the input connected to Low Terminal of the output (either directly or via the 3499A/B/C switching channels).

N2262A 4 x 8 2-Wire Matrix Switch Module

■ INPUT CHARACTERISTICS		
Total Channels:	4 x 8	
Maximum Voltage:	Terminal-Terminal or Terminal-Chassis:	200 V, dc or ac rms
Maximum Current:	Per Channel: Per Module:	1 A, dc or ac rms 4 A, dc or ac rms
Maximum Power:	Per Channel: Per Module:	60 W dc; 62.5 VA ac 240 W dc; 250 VA ac
Thermal Offset:	< 3 μV differential	
Initial Closed Channel Resistance:	< 1 Ω	
Relay Life:	Mechanical: Electrical:	10^8 (at 36000 operations/hour) 5 x 10^5 (1A load)
Maximum Scan Rate:	80 Chans/sec	
■ DC ISOLATION (with terminal block)		
Open Channel, Channel-Channel: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω
HI-LO: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω
Channel-Chassis: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω

■ AC ISOLATION / PERFORMANCE[a] (without terminal block)

Capacitance: (with 1 channel closed)	Open Channel, Channel-Channel: HI-LO: Channel-Chassis:	< 7 pF < 30 pF < 50 pF
Insertion Loss: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< 0.10 dB < 0.20 dB < 0.60 dB
Crosstalk: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< -73 dB < -53 dB < -28 dB

a. With chassis of all instruments connected, and with Low Terminal of the input connected to Low Terminal of the output (either directly or via the 3499A/B/C switching channels).

N2263A 32-bit Digital I/O Module

■ I/O LINES		
Bit Number:	32	
Maximum Voltage:	Line-Chassis:	+ 42 V dc
Maximum Sink Current:	Per Bit:	600 mA
Output Characteristics:	Vout (high): Vout (low):	≥ 2.4 V @ I ≤ 10 mA output ≤ 0.8 V @ I ≤ 600 mA input
Input Characteristics:	Vin (high): Vin (low):	≥ 2.0 V ≤ 0.8 V
■ HANDSHAKE LINES		
Maximum Voltage:	Line-Chassis:	+5 V dc
Output Characteristics:	Vout (high): Vout (low): Iout (low):	≥ 2.4 V @ I ≤ 400 μA output ≤ 0.5 V @ I ≤ 1 mA input < 25 mA (when shorted to +5 V)
Input Characteristics:	Vin (high): Vin (low):	≥ 2.0 V ≤ 0.8 V

N2264A Multifunction Module

The maximum number of channels that can be closed simultaneously is 10 (including the GP and High-Current GP relays). The maximum carrying current is 15 A (including the GP, High-Current GP and Digital I/O.

16-bit Digital I/O Function

■ I/O LINES		
Bit Number:	16	
Maximum Voltage:	Line-Chassis:	+ 42 V dc
Maximum Sink Current:	Per Bit:	600 mA
Output Characteristics:	Vout (high): Vout (low):	≥ 2.4 V @ I ≤ 10 mA output ≤ 0.8 V @ I ≤ 600 mA input
Input Characteristics:	Vin (high): Vin (low):	≥ 2.0 V ≤ 0.8 V
■ HANDSHAKE LINES		
Maximum Voltage:	Line-Chassis:	+5 V dc
Output Characteristics:	Vout (high): Vout (low): Iout (low):	≥ 2.4 V @ I ≤ 400 μA output ≤ 0.5 V @ I ≤ 1 mA input < 25 mA (when shorted to +5 V)
Input Characteristics:	Vin (high): Vin (low):	≥ 2.0 V ≤ 0.8 V

12-Channel GP Relay Function

■ INPUT CHARACTERISTICS		
Total Channels:	12	
Maximum Voltage:	Terminal-Terminal or Terminal-Chassis:	200 V, dc or ac rms
Maximum Current:	Per Channel:	1 A, dc or ac rms
Maximum Power:	Per Channel:	60 W dc; 62.5 VA ac
Thermal Offset:	Per Channel:	< 3 μV
Initial Closed Channel Resistance:	< 0.5 Ω	
Relay Life:	Mechanical: Electrical:	10^8 (at 36000 operations/hour) 5 x 10^5 (1A load)
Maximum Scan Rate:	80 Chans/sec	
■ DC ISOLATION (with terminal block)		
Open Channel, Channel-Channel: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω
Channel-Chassis: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω
■ AC ISOLATION / PERFORMANCE[a] (without terminal block)		
Capacitance: (with 1 channel closed)	Open Channel, Channel-Channel: Channel-Chassis:	< 10 pF < 20 pF
Insertion Loss: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< 0.10 dB < 0.20 dB < 0.50 dB
Crosstalk: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< -70 dB < -50 dB < -30 dB

a. With chassis of all instruments connected, and with Lo Terminal of the input connected to Lo Terminal of the output (either directly or via the 3499A/B/C switching channels).

High-Current GP Relay Function

■ INPUT CHARACTERISTICS		
Total Channels:	3	
Maximum Voltage:	Terminal-Terminal or Terminal-Chassis:	125 V dc or 200 V ac rms
Maximum Current:	Per Channel:	5 A, dc or ac rms
Maximum Power:	Per Channel:	150 W dc; 1250 VA ac
Thermal Offset:	Per Channel:	< 3 μV
Initial Closed Channel Resistance:	< 0.1 Ω	
Relay Life:	Mechanical: Electrical:	5×10^7 (at 180 cycles/minute) 10^5 (at rated load)
Time to Close One Channel:	16 mS	
■ DC ISOLATION (with terminal block)		
Open Channel, Channel-Channel: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω
Channel-Chassis: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω
■ AC ISOLATION / PERFORMANCE[a] (without terminal block)		
Capacitance: (with 1 channel closed)	Open Channel, Channel-Channel: Channel-Chassis:	< 10 pF < 20 pF
Insertion Loss: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< 0.10 dB < 0.20 dB < 0.50 dB
Crosstalk: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< -70 dB < -50 dB < -30 dB

a. With chassis of all instruments connected, and with Lo Terminal of the input connected to Lo Terminal of the output (either directly or via the 3499A/B/C switching channels).

N2265A Multifunction Module

4 X 4 Matrix Function

■ INPUT CHARACTERISTICS		
Total Channels:	4 x 4	
Maximum Voltage:	Terminal-Terminal or Terminal-Chassis:	200 V, dc or ac rms
Maximum Current:	Per Channel: Per Module:	1 A, dc or ac rms 4 A, dc or ac rms
Maximum Power:	Per Channel: Per Module:	60 W dc; 62.5 VA ac 240 W dc; 250 VA ac
Thermal Offset:	< 3 μV differential	
Initial Closed Channel Resistance:	< 1 Ω	
Relay Life:	Mechanical: Electrical:	10^8 (at 36000 operations/hour) 5 x 10^5 (1A load)
Maximum Scan Rate:	80 Chans./sec	
■ DC ISOLATION (with terminal block)		
Open Channel, Channel-Channel: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω
HI-LO: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω
Channel-Chassis: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω

■ AC ISOLATION / PERFORMANCE[a] (without terminal block)		
Capacitance: (with 1 channel closed)	Open Channel, Channel-Channel: HI-LO: Channel-Chassis:	< 7 pF < 25 pF < 40 pF
Insertion Loss: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< 0.10 dB < 0.20 dB < 0.60 dB
Crosstalk: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< -76 dB < -56 dB < -33 dB

a. With chassis of all instruments connected, and with Lo Terminal of the input connected to Lo Terminal of the output (either directly or via the 3499A/B/C switching channels).

16-bit Digital I/O Function

■ I/O LINES		
Number of Bits:	16	
Maximum Voltage:	Line-Chassis:	+ 42 V dc
Maximum Sink Current:	Per Bit:	600 mA
Output Characteristics:	Vout (high): Vout (low):	≥ 2.4 V @ I ≤ 10 mA output ≤ 0.8 V @ I ≤ 600 mA input
Input Characteristics:	Vin (high): Vin (low):	≥ 2.0 V ≤ 0.8 V
■ HANDSHAKE LINES		
Maximum Voltage:	Line-Chassis:	+5 V dc
Output Characteristics:	Vout (high): Vout (low): Iout (low):	≥ 2.4 V @ I ≤ 400 μA output ≤ 0.5 V @ I ≤ 1 mA input < 25 mA (when shorted to +5 V)
Input Characteristics:	Vin (high): Vin (low):	≥ 2.0 V ≤ 0.8 V

N2266A 40-Channel MUX Module

■ INPUT CHARACTERISTICS

Total Channels:	80 1-wire; or 40 2-wire; or dual 20 2-wire; or 20 4-wire	
Maximum Switching Voltage:	Terminal-Terminal or Terminal-Chassis:	200 V, dc or peak AC Resist.
Maximum Switching Current:	Per Channel: Per Module:	0.5 A, dc or peak AC Resist. 1 A, dc or peak AC Resist.
Maximum Switching Power:	Per Channel: Per Module:	10 W dc or peak AC Resist. 20 W dc or peak AC Resist.
Thermal Offset:	Per Channel:	50 μV differential or single-ended
Initial Closed Channel Resistance:	< 1 Ω	
Relay Life:	@1V/1mA:	10^9
Maximum Scan Rate	350 Chans/sec	

■ DC CHARACTERISTICS

Open Channel, Channel-Channel: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω
HI-LO: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω
Channel-Chassis: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH)”	> 10^{10} Ω > 10^9 Ω

■ AC CHARACTERISTICS[a]

Bandwidth (-3dB):	40 MHz	
Capacitance: (with 1 channel closed) (2-wire)	Open Channel, Channel-Channel: Channel-Chassis: HI-LO:	< 7 pF < 140 pF < 50 pF
Insertion Loss: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz: 40 MHz:	0.2 dB 0.3 dB 2.0 dB 3.0 dB
Crosstalk: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	-75 dB -55 dB -33 dB

a. With chassis of all instruments connected, and with the Lo Terminal of the input connected to the Lo Terminal of the output (either directly or via the 3499A/B/C switching channels).

Caution In order to stay within the 20W power limit set for convection cooling, no more than three (3) N2266A 40-Channel MUX Modules should be installed in an Agilent 3499A mainframe; the remaining two slots must remain empty. Other module combinations are acceptable; for example, two N2266A MUX modules plus any combination of other Agilent modules is permissible. This limitation does not apply to the 3499B or 3499C mainframes.

N2267A 8-Channel High Current GP Module

■ INPUT CHARACTERISTICS

Total Channels:	8	
Maximum Switching Voltage:	Terminal-Terminal or Terminal-Chassis:	250 VAC, 125 VDC
Maximum Switching Current:	Per Channel: 0 - 30 Vdc at 5A 30 - 125 Vdc at 0.24A 0 - 250 Vac Per Module:	 5 A 0.24 A 8 A 64 A
Maximum Switching Power:	Per Channel: Per Module:	2000 VA, 150 W 16000 VA, 1200 W
Thermal Offset:	Per Channel:	3 μV
Initial Closed Channel Resistance:	< 0.08 Ω	
Relay Life:	Mechanical: Electrical:	5 x10^7 (at 180 cpm) 10^5
Maximum Scan Rate:	20 Chans/sec	

■ DC CHARACTERISTICS

Open Channel, Channel-Channel: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω
Channel-Chassis: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω

■ AC CHARACTERISTICS[a]

Capacitance: (with 1 channel closed)	Open Channel, Channel-Channel: Channel-Chassis:	< 10 pF < 10 pF
Insertion Loss: (with 50Ω termination)	100 kHz: 1 MHz:	0.10 dB 0.20 dB
Crosstalk: (with 50Ω termination)	100 kHz: 1 MHz:	-75 dB -55 dB

■ Environmental Conditions

Operating Pollution Degree:	2
Operating Altitude:	3000 meters (10,000 ft)
Measurement Category:	I, 1500 Vpk transient, 500 V over voltage transient
Operating Temperature:	0 - 55^{o}C
Operating Humidity:	<80% RH (0^{o}C to 40^{o}C), non-condensing

a. With chassis of all instruments connected, and with Lo Terminal of the input connected to Lo Terminal of the output (either directly or via the 3499A/B/C switching channels)

N2268A 50Ω 3.0 GHz Dual 1-to-4 MUX Module

■ INPUT CHARACTERISTICS

Total Channels:	Dual 1-to-4 Chans	
Maximum Switching Voltage:	Any center/shield to any other center/shield/chassis:	30 V, dc or peak AC
Maximum Switching Current:	Per Channel: Per Module:	0.5 A, dc or peak AC 1 A, dc or peak AC
Maximum Switching Power:	Per Channel: Per Module:	10 W 20 W
Characteristic Impedance:	50 Ω	
Relay Life:	Mechanical: 10mA/24VDC resist. load: 10W 2.5G 50Ω:	5×10^6 3×10^5 10^5
Thermal Offset:	Per Channel:	3 μV
Initial Closed Channel Resistance:	<1 Ω	
Maximum Scan Rate:	20 Chans/sec	

■ DC CHARACTERISTICS

Open Channel, Channel-Channel: (with 1 Channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	$> 10^{10}$ Ω $> 10^9$ Ω
HI-LO: (with 1 Channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	$> 10^{10}$ Ω $> 10^9$ Ω
Channel-Chassis: (with 1 Channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	$> 10^{10}$ Ω $> 10^9$ Ω

■ AC CHARACTERISTICS[a]

Bandwidth (-3dB):	50 Ω source, 50 Ω termination:	3.5 GHz
Insertion Loss: (with 50Ω termination)	1 GHz: 2 GHz: 3 GHz:	0.9 dB 1.2 dB 1.4 dB
Crosstalk: (with 50Ω termination)	DC-2 GHz: 2 GHz-3.0 GHz:	-64 dB -50 dB
VSWR:	1 GHz: 2 GHz: 3.0 GHz:	1.20 1.35 1.35
Capacitance:	Center-Shield: Center-Center:	20 pF 0.06 pF
Rise Time:	<150 ps	
Signal Delay:	<1.5 ns	

a. With chassis of all instruments connected, and with Lo Terminal of the input connected to Lo Terminal of the output (either directly or via the 3499A/B/C switching channels).

N2270A 10-Channel High Voltage MUX Module

■ INPUT CHARACTERISTICS

Total Channels:	10	
Maximum Switching Voltage:	Terminal-Terminal or Terminal-Chassis:	1000 V peak (per IEC1010 for Pollution Degree I)
Maximum Switching Current:	Per Channel: Per Module:	1 A 1 A
Maximum Switching Power:	Per Channel: Per Module:	10 W 10 W
Thermal Offset:	Per Channel:	200 μV
Initial Closed Channel Resistance:	< 1 Ω	
Relay Life:	Signal load, 1V 10mA:	10^8
Maximum Scan Rate:	100 Chans/sec	

■ DC CHARACTERISTICS

Open Channel, Channel-Channel: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω
Channel-Chassis: (with 1 channel closed)	< (40°C, 50% RH): < (40°C, 80% RH):	> 10^{10} Ω > 10^9 Ω

■ AC CHARACTERISTICS[a]

Capacitance: (with 1 channel closed)	Open Channel, Channel-Channel, Hi-Lo:	< 7 pF
	Channel-Chassis:	< 50 pF
Insertion Loss: (with 50Ω termination)	100 kHz:	0.1 dB
	1 MHz:	0.2 dB
Crosstalk : (with 50Ω termination)	100 kHz:	-70 dB
	1 MHz:	-50 dB

■ Environmental Conditions

Operating Pollution Degree:	2
Operating Altitude:	3000 meters (10,000 ft)
Measurement Category:	I, 1500 Vpk transient, 500 V over voltage transient
Operating Temperature:	0-55^{o}C
Operating Humidity:	<80% RH (0^{o}C-40^{o}C), non-condensing

a. With chassis of all instruments connected, and with Lo Terminal of the input connected to Lo Terminal of the output (either directly or via the 3499A/B/C switching channels).

N2272A 1 GHz RF 1-to-9 MUX Module

■ INPUT CHARACTERISTICS	
Total Channels:	1-to-9
Relay Type:	Latching
Connector Type:	BNC
Maximum Switching Voltage:	24 VDC
Maximum Switching Current:	1 A
Maximum Switching Power:	24 W
Characteristic Impedance:	50Ω
Relay Life:	Mechanical: $5X10^6$ Electrical@1A24VDC: 10^5
■ DC CHARACTERISTICS	
Offset Voltage (mV):	8.0
Initial Closed Channel Resistance (Ω):	0.8
Insulation Resistance (Ω):	@(25°C, 40%RH) (Open Ch, Ch-Ch): 1010 (Ch-Chassis, Ch-Center): 10^{10} @(40°C, 80%RH) (Open Ch, Ch-Ch): 10^9 (Ch-Chassis, Ch-Center): 10^9

■ AC CHARACTERISTICS

Bandwidth (-3dB):	1GHz	
Insertion Loss (dB): @(25°C, 40%RH)	100 MHz: 300 MHz: 500 MHz: 800 MHz: 1 GHz:	0.5 0.8 1.0 1.8 2.5
Ch-Ch Cross Talk (dB): @(25°C, 40%RH)	100 MHz: 300 MHz: 500 MHz: 800 MHz: 1 GHz:	-75 -65 -65 -55 -50
VSWR: @(25°C, 40%RH)	100 MHz: 300 MHz: 500 MHz: 800 MHz: 1 GHz:	1.20 1.30 1.35 1.35 1.55
Capacitance (pF):	Center-Shield: Center-Center:	60 pF 0.006 pF
Rise Time:	500 ps	
Signal Delay:	2.5 ns	

N2276A Dual 1-to-6(4) Microwave MUX/ Attenuator Module

Total Channels:	Dual 1-to-6 (Dual 1-to-4 when with option 204)
Connector Type:	SMA (female)
Frequency Range:	DC to 20 GHz
Insertion Loss:	0.3 dB + 0.015*Frequency (GHz)
Isolation:	100 dB min. DC to 12 GHz 80 dB min. 12 GHz to 15 GHz 70 dB min. 15 GHz to 20 GHz
SWR:	1.2 max DC to 4 GHz 1.35 max 4 to 12.4 GHz 1.45 max 12.4 to 18 GHz 1.7 max 18 to 20 GHz
Repeatability: (5 million cycles at 25^{o}C)	0.03 dB maximum
Switch Speed:	25ms
Switch Life:	5 million cycles

N2276B Microwave MUX/Attenuator Module

The switching and attenuation characteristics of the N2276B are determined by the switches and attenuators installed in it. Please refer to the switch's and/or attenuator's data sheet for the specifications of your customized N2276B module.

N2280A Quadruple 1-to-2 Optical Switch Module

		Typical	Maximum
Insertion Loss:	Single-mode (SM):[a]	0.5 dB	0.8 dB
Return Loss:	SM:[b]	50 dB	45 dB (min.)
Polarization Dependent Loss:[b]	SM:	0.02 dB	0.07 dB
Insertion Loss Stability:[c]		±0.03 dB	±0.05 dB
Repeatability:		±0.03dB	±0.005 dB
Crosstalk:		-70 dB	-60 dB
Optical Input Power:			300 mW
Switching Time:		15 ms	20 ms
Cycle Rate:			5 c/s
Relay Life:			10M cycles (min.)
Operating Temperature:			0 to 55^{O}C
Storage Temperature;			-40 to 70^{O}C
Humidity: (non-condensing)			< 80%RH
Power:		5 ±5%VDC/45mA	5 ±5%VDC/70mA

a. Excluding connectors. Include 0.2dB (typical insertion loss) for each connector.
b. Excluding connectors.
c. Drift of any channel relative to one assigned reference channel at $\pm$ 3^{o} C deviation of ambient temperature over a seven-day period.

N2281A Dual 1-to-4 Optical Switch Module

		Typical	Maximum
Insertion Loss:	Single-mode (SM):[a]	0.5 dB	0.8 dB
Return Loss:	SM:[b]	50 dB	45 dB (min.)
Polarization Dependent Loss:[b]	SM:	0.02 dB	0.07 dB
Insertion Loss Stability:[c]		±0.03 dB	±0.05 dB
Repeatability:		±0.03 dB	±0.005 dB
Crosstalk:		-70 dB	-60 dB
Optical Input Power:			300 mW
Switching Time:		20 ms	25 ms
Cycle Rate:			5 c/s
Relay Life:			10M cycles (min.)
Operating Temperature:			0 to 55^{o}C
Storage Temperature:			-40 to 70^{o}C
Humidity (non-condensing):			< 80%RH
Power:		5 ±5%VDC/45mA	5 ±5%VDC/70mA

a. Excluding connectors. Include 0.2dB (typical insertion loss) for each connector.
b. Excluding connectors.
c. Drift of any channel relative to one assigned reference channel at ±3^{o} C deviation of ambient temperature over a seven-day period.

N2282A 1-to-8 Optical Switch Module

	Minimum	Typical	Maximum
Channel Count:		1-to-8	
Switch Type:		Latching	
Return Loss (SM):[a]		-62 dB	-57 dB
Insertion Loss (SM):[b]		0.5 dB	0.7 dB
Insertion Loss Stability:[c]		±0.02 dB	±0.025 dB
Polarization Dependent Loss (PDL):		0.02 dB	0.04 dB
Insertion Repeatability[d] **Sequential Switching:** **Random Switching:**		 ±0.005 dB ±0.01 dB	 ±0.01 dB ±0.05 dB
Crosstalk:		-90 dB	-80 dB
Input Power (Optical):		300 mW Continuous	
Switching Time:		250 ms	
Wavelength (SM):	1270 nm		1670 nm
Relay Life:	10M cycles		
Operating Temperature:	0^{o} C		55 ^{o}C
Humidity (non-condensing):		<80%RH (0^{o} C~55^{o} C)	

a. Excluding connector.
b. Excluding Connectors, 0.2 dB typical connector insertion loss.
c. Measured after one hour's warm-up.
d. Measured after temperature has been stablized for one hour.

44470A 10-Channel MUX Module

■ INPUT CHARACTERISTICS

Total Channels:	10	
Maximum Voltage:	Terminal-Terminal or Terminal-Chassis:	250 V, dc or ac rms
Maximum Current:	Per Channel or Module:	2 A, dc or ac rms
Maximum Power:	Per Channel or Module:	60 W dc; 500 VA ac
Maximum Overvoltage Transients:	1400 V_{pk}	
Thermal Offset:	< 3 μV differential or single-ended	
Initial Closed Channel Resistance:	< 1 Ω	
Relay Life:	Dry Load of < 300 mA & < 10 V: Maximum Rated Load:	10^8 10^5
Maximum Scan Rate:[a]	43 Chans/sec	

■ DC ISOLATION

Open Channel, Channel-Channel: (with 1 channel closed)	< (40°C, 60% RH): < (40°C, 95% RH):	> 10^{11} Ω >10^9 Ω
HI-LO: (with 1 channel closed)	< (40°C, 60% RH): < (40°C, 95% RH):	> 10^{10} Ω > 10^8 Ω
Channel-Chassis: (with 1 channel closed)	< (40°C, 60% RH): < (40°C, 95% RH):	> 10^{10} Ω > 5 x 10^8 Ω

a. Using the 44474A external increment & channel closed, display off.

■ AC ISOLATION / PERFORMANCE[a]

Capacitance: (with 1 channel closed)	Open Channel, Channel-Channel: HI-LO: Channel-Chassis:	< 5 pF < 27 pF < 80 pF
Insertion Loss: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< 0.20 dB < 0.25 dB < 0.50 dB
Crosstalk: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< -73 dB < -53 dB < -33 dB

a. With chassis of all instruments connected, and with the Lo of input lines connected to the Lo of output lines (either directly or via the 3499A/B/C switching channels).

44470D 20-Channel MUX Module

■ INPUT CHARACTERISTICS

Total Channels:	20	
Maximum Voltage:	Terminal-Terminal or Terminal-Chassis:	250 V, dc or ac rms
Maximum Current:	Per Channel or Module:	2 A, dc or ac rms
Maximum Power:	Per Channel or Module:	60 W dc; 125 VA ac
Maximum Overvoltage Transients:	1400 V_{pk}	
Thermal Offset:	< 3 μV differential or single-ended	
Initial Closed Channel Resistance:	< 1 Ω	
Relay Life:	Dry Load of < 300 mA & < 10 V: Maximum Rated Load:	10^8 10^5
Maximum Scan Rate:[a]	43 Chans/sec	

■ DC ISOLATION

Open Channel, Channel-Channel: (with 1 channel closed)	< (40°C, 60% RH): < (40°C, 95% RH):	> 10^{11} Ω > 5 x 10^9 Ω
HI-LO: (with 1 channel closed)	< (40°C, 60% RH): < (40°C, 95% RH):	> 5 x 10^{10} Ω > 10^9 Ω
Channel-Chassis; (with 1 channel closed)	< (40°C, 60% RH): < (40°C, 95% RH):	> 5 x 10^{10} Ω > 10^9 Ω

a. Using the 44474A external increment & channel closed, display off.

■ AC ISOLATION / PERFORMANCE[a]

Capacitance: (with 1 channel closed)	Open Channel, Channel-Channel: HI-LO: Channel-Chassis:	< 7 pF < 27 pF < 80 pF
Insertion Loss: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< 0.20 dB < 0.25 dB < 1.20 dB
Crosstalk: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< -73 dB < -53 dB < -31 dB

a. With chassis of all instruments connected, and with the Lo of input lines connected to the Lo of output lines (either directly or via the 3499A/B/C switching channels).

44471A 10-Channel GP Relay Module

■ INPUT CHARACTERISTICS

Total Channels:		10
Maximum Voltage:	Terminal-Terminal or Terminal-Chassis:	250 V, dc or ac rms
Maximum Current:	Per Channel: Per Module:	2 A, dc or ac rms 20 A, dc or ac rms
Maximum Power:	Per Channel: Per Module:	60 W dc; 500 VA ac 600 W dc; 5000 VA ac
Maximum Overvoltage Transients:	1400 V_{pk}	
Thermal Offset:	< 3 μV differential or single-ended	
Initial Closed Channel Resistance:	< 1 Ω	
Relay Life:	Dry Load of < 300 mA & < 10 V: Maximum Rated Load:	10^8 10^5
Maximum Scan Rate:[a]	43 Chans/sec	

■ DC ISOLATION

Open Channel, Channel-Channel: (with 1 channel closed)	< (40°C, 60% RH): < (40°C, 95% RH):	> 10^{11} Ω > 10^9 Ω
Channel-Chassis: (with 1 channel closed)	< (40°C, 60% RH): < (40°C, 95% RH):	> 5 x 10^{11} Ω > 10^{10} Ω

a. Using the 44474A external increment & channel closed, display off.

■ AC ISOLATION / PERFORMANCE[a]

Capacitance: (with 1 channel closed)	Open Channel: Channel-Channel: Channel-Chassis:	< 7 pF < 10 pF < 25 pF
Insertion Loss: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< 0.20 dB < 0.25 dB < 0.50 dB
Crosstalk: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< -73 dB < -53 dB < -33 dB

a. With chassis of all instruments connected, and with the Lo of input lines connected to the Lo of output lines (either directly or via the 3499A/B/C switching channels).

44471D 20-Channel GP Relay Module

■ INPUT CHARACTERISTICS		
Total Channels:	20	
Maximum Voltage:;	Terminal-Terminal or Terminal-Chassis:	250 V, dc or ac rms
Maximum Current:	Per Channel: Per Module:	1 A, dc or ac rms 20 A, dc or ac rms
Maximum Power:	Per Channel: Per Module:	60 W dc; 125 VA ac 1200 W dc; 2500 VA ac
Maximum Overvoltage Transients:	1400 V_{pk}	
Thermal Offset:	< 3 μV differential or single-ended	
Initial Closed Channel Resistance:	< 1 Ω	
Relay Life:	Dry Load of < 300 mA & < 10 V: Maximum Rated Load:	10^8 10^5
Maximum Scan Rate:[a]	43 Chans/sec	
■ DC ISOLATION		
Open Channel, Channel-Channel: (with 1 channel closed)	< (40°C, 60% RH): < (40°C, 95% RH):	> 10^{11} Ω > 10^9 Ω
Channel-Chassis: (with 1 channel closed)	< (40°C, 60% RH): < (40°C, 95% RH):	> 5 x 10^{11} Ω > 10^{10} Ω

a. Using the 44474A external increment & channel closed, display off.

■ AC ISOLATION / PERFORMANCE[a]

Capacitance: (with 1 channel closed)	Open Channel: Channel-Channel: Channel-Chassis:	< 7 pF < 10 pF < 25 pF
Insertion Loss: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< 0.20 dB < 0.25 dB < 1 dB
Crosstalk: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< -71 dB < -51 dB < -31 dB

a. With chassis of all instruments connected, and with the Lo of input lines connected to the Lo of output lines (either directly or via the 3499A/B/C switching channels).

44472A Dual 4-Channel VHF Switch Module

■ INPUT CHARACTERISTICS		
Total Channels:	Dual 4 Chans	
Connector Type:	BNC	
Maximum Voltage:	Center-Center or Center-Low: Low-Chassis or Low-Low:	250 V dc, 30 V ac rms or 42 V ac peak 42 V dc
Maximum Current:	Per Channel:	30 mA dc, 300 mA ac rms
Thermal Offset:	Per Channel:	< 15 μV
Characteristic Impedance:	50 Ω	
Initial Closed Channel Resistance:	< 1 Ω	
Relay Life:	Dry Load of < 300 mA & < 10 V: Maximum Rated Load:	10^8 10^5
Maximum Scan Rate:[a]	43 Chans/sec	
■ DC ISOLATION		
Between Any Two Points:	< (40°C, 95% RH):	> 10^7 Ω

a. Using Agilent 44474A external increment & channel closed, display off.

■ AC ISOLATION / PERFORMANCE[a]

Capacitance:	Center-Center, Center-Common: Center-Low: Low-Chassis:	< 0.002 pF < 70 pF < 0.20 μF
Rise Time:	< 0.7 ns	
Signal Delay:	< 2.5 ns (channel match < 90 ps)	
Insertion Loss: (with 50Ω termination)	30 MHz: 100 MHz: 300 MHz:	< 0.50 dB < 0.75 dB < 1.25 dB
Crosstalk Within a Group: (Channel-Channel or Channel-Common, with 50Ω termination)	30 MHz: 100 MHz: 300 MHz:	< -100 dB < -85 dB < -65 dB
Crosstalk Group to Group: (with 50Ω termination)	30 MHz: 100 MHz: 300 MHz:	< -85 dB < -85 dB < -50 dB
VSWR: (with 50 Ω termination)	30 MHz: 100 MHz: 300 MHz:	< 1.06 < 1.12 < 1.43

a. When all channels in a group are opened, the last channel opened (or channel 00 or 13 following a group RESET) has channel-common isolation of > 80 dB @ 30 MHz, > 60 dB @ 100 MHz, and > 40 dB @ 300 MHz.

44473A 4 x 4 2-Wire Matrix Switch Module

■ INPUT CHARACTERISTICS		
Total Channels:	16	
Maximum Voltage:	Terminal-Terminal or Terminal-Chassis:	250 V, dc or ac rms
Maximum Current:	Per Channel: Per Module:	2 A, dc or ac rms 8 A, dc or ac rms
Maximum Power:	Per Channel: Per Module:	60 W dc; 500 VA ac 240 W dc; 2000 VA ac
Maximum Overvoltage Transients:	1400 V_{pk}	
Thermal Offset:	< 3 μV differential	
Initial Closed Channel Resistance:	< 1 Ω	
Relay Life:	Dry Load of < 300 mA & < 10 V: Maximum Rated Load:	10^8 10^5
Maximum Scan Rate:[a]	43 Chans/sec	
■ DC ISOLATION		
Open Channel, Channel-Channel: (with 1 channel closed)	< (40°C, 60% RH): < (40°C, 95% RH):	> 10^{11} Ω > 10^9 Ω
HI-LO: (with 1 channel closed)	< (40°C, 60% RH): < (40°C, 95% RH):	> 10^{10} Ω > 10^8 Ω
Channel-Chassis: (with 1 channel closed)	< (40°C, 60% RH): < (40°C, 95% RH):	> 10^{10} Ω > $5x10^8$ Ω

a. Using the 44474A external increment & channel closed, display off.

■ AC ISOLATION / PERFORMANCE[a]

Capacitance: (with 1 channel closed)	Open Channel, Channel-Channel: HI-LO: Channel-Chassis:	< 5 pF < 40 pF < 70 pF
Insertion Loss: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< 0.30 dB < 0.35 dB < 0.90 dB
Crosstalk: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< -76 dB < -56 dB < -36 dB

a. With chassis of all instruments connected, and with the Lo of input lines connected to the Lo of output lines (either directly or via the 3499A/B/C switching channels).

44474A 16-Bit Digital I/O Module

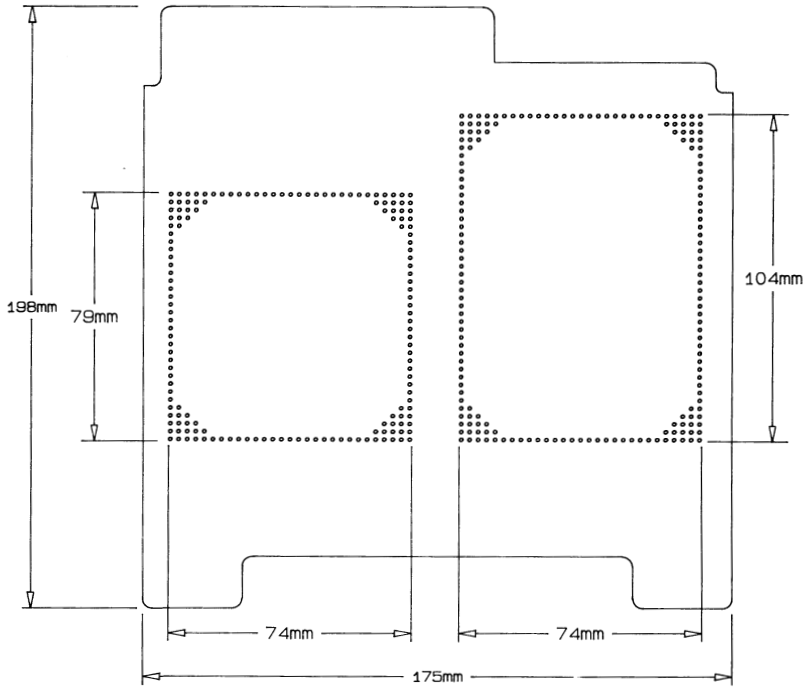
■ I/O LINES		
Number of Bits:	16	
Maximum Voltage:	Line-Chassis:	+30 V dc
Output Characteristics:	Vout (high): Vout (low): I (low):	≥ 2.4 V @ I ≤ 8 mA output ≤ 0.4 V @ I ≤ 16 mA input = 125 mA @ Vout (low) ≤ 1.25 V fused at 250 mA
Input Characteristics:	Vin (high): Vin (low):	≥ 2.0 V ≤ 0.8 V
■ HANDSHAKE LINES		
Maximum Voltage:	Line-Chassis:	+5 V dc
Output Characteristics:	Vout (high): Vout (low):	≥ 2.4 V @ I ≤ 400 μA output ≤ 0.5 V @ I ≤ 2 mA input
Input Characteristics:	Vin (high): Vin (low):	≥ 2.0 V ≤ 0.8 V
■ External Increment (EI):[a]	Minimum TTL Pulse Width:	0.25 μs
Channel Closed (CC):[b]	Minimum TTL Pulse Width:	10 μs

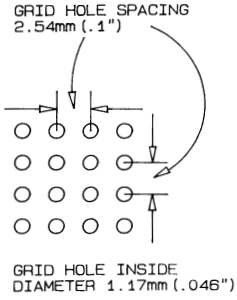
a. Both EI and CC lines are used for external controlled scanning. The 3499A/B/C will advance to the next channel in the scan list on the falling edge of EI pulse.
b. When the next channel closes, the 44474A outputs a CC pulse to trigger the voltmeter.

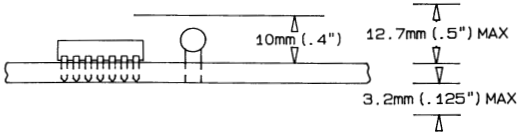
44475A Breadboard Module

Components required, but not supplied, are to be mounted on the Breadboard. Refer to the manufacturers data sheet for load/drive specifications of these components see page 251 for a list of required components).

■ MODULE DIMENSIONS	
Component Area Available:	104mm x 74mm and 79mm x 74mm (4.1" x 2.9" and 3.1" x 2.9")
Grid Hole Spacing (center-center):	2.54mm x 2.54 mm (0.1" x 0.1")
Grid Hole Size (inside diameter):	1.17mm (0.046")
Maximum Component Height (above board):	12.7mm (0.5")
Maximum lead Length (below board):	3.2mm (0.125")
■ **INPUT CHARACTERISTICS**	
Maximum Voltage:	42 V dc, 30 V ac rms, 42 V ac peak (on breadboard area); 5.5 V (on digital input port lines)
Maximum Power Dissipation (Per Module):	2 Watts


198mm
79mm
104mm
74mm
74mm
175mm


GRID HOLE SPACING
2.54mm (.1")
GRID HOLE INSIDE
DIAMETER 1.17mm (.046")


10mm (.4")
12.7mm (.5") MAX
3.2mm (.125") MAX

44476A Microwave Switch Module

■ INPUT CHARACTERISTICS		
Frequency Range:	DC to 18 GHz	
Characteristic Impedance:	50 Ω	
Input Power Rating:	1 Watt average, 100 Watts peak (Also less than ±7 V dc)	
Average Switch Life:	10^6	
Repeatability (typical):	0.03 dB after 10^6 switchings	
Maximum Scan Rate:[a]	43 Chans/sec	
Connector:	SMA	
■ AC ISOLATION / PERFORMANCE		
Isolation:	DC - 18 GHz:	> 90 dB
Insertion Loss:	DC - 2 GHz: DC - 18 GHz:	< 0.25 dB < 0.50 dB
SWR (3 mm SMA):	DC - 2 GHz: DC - 12.4 GHz: DC - 18.0 GHz:	< 1.15 dB < 1.25 dB < 1.40 dB

a. Using the 44474A External Increment & Channel Closed, display off.

44476B Microwave Switch Module

The switching and attenuation characteristics of the 44476B are determined by the switches and attenuators installed in it. Please refer to the switch's and/or attenuator's data sheet for the specifications of your customized 44476B module.

44477A Form-C Relay Module

■ INPUT CHARACTERISTICS		
Total Channels:	7	
Maximum Voltage:	Terminal-Terminal or Terminal-Chassis:	250 V dc or ac rms, 350 V ac peak
Maximum Current:	Per Channel: Per Module:	2 A, dc or ac rms 14 A, dc or ac rms
Maximum Power:	Per Channel: Per Module:	60 W dc; 500 VA ac 420 W dc; 3500 VA ac
Maximum Overvoltage Transients:	1400 V_{pk}	
Thermal Offset:	< 3 μV per channel	
Initial Closed Channel Resistance:	< 1 Ω	
Relay Life:	Dry Load of < 300 mA & < 10 V: Maximum Rated Load:	10^8 10^5
Maximum Scan Rate:[a]	43 Chans/sec	
■ DC ISOLATION		
Open Channel, Channel-Channel: (with 1 channel closed)	≤ (40°C, 60% RH): ≤ (40°C, 95% RH):	> 10^{11} Ω >10^9 Ω
Channel-Chassis: (with 1 channel closed)	≤ (40°C, 60% RH): ≤ (40°C, 95% RH):	> 5 x 10^{11} Ω > 10^{10} Ω

a. Using the 44474A external increment & channel closed, display off.

■ AC ISOLATION/PERFORMANCE[a]

Capacitance: (with 1 channel closed)	Open Channel, Channel-Channel: Channel-Chassis:	< 10 pF < 25 pF
Insertion Loss: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< 0.20 dB < 0.25 dB < 0.50 dB
Crosstalk: (with 50Ω termination)	100 kHz: 1 MHz: 10 MHz:	< -73 dB < -53 dB < -33 dB

a. With chassis of all instruments connected, and with the Lo of input lines connected to the Lo of output lines (either directly or via the 3499A/B/C switching channels).

44478A/B 1.3 GHz Dual 4-to-1 MUX Modules

Specifications in the table describe the modules' warranted performance over the temperature range 0º to 55º C. Information marked by the "Typical" designation is helpful in applying the modules, but is non-warranted information.

■ INPUT CHARACTERISTICS		
Total Channels:	Dual 4 Chans	
Maximum Voltage:	Any Center/Shield to Any Other Center/Shield/ Chassis:	42 V dc + ac peak
Maximum Current:	Per Channel or Common:	1 A dc, or ac rms
Maximum Power:	Per Channel or Common: Each Resistive Termination:	24 W, 24 VA or 44 dBm 0.25 W, 0.25 VA or 24 dBm
Characteristic Impedance:	44478A: 44478B:	50 Ω 75 Ω
Relay Life (*Typical*):	With No Load: At Maximum Rated Power:	5×10^6 operations 10^5 operations
Maximum Scan Rate:[a]	43 Chans/sec	
■ DC PERFORMANCE		
Thermal Offset:	Per Channel:	< 6 μV (< 2 μV, *Typical*)
Initial Closed Channel Resistance:	< 1 Ω	
Insulation Resistance (any terminal to any terminal)	≤ (40°C, 95% RH): ≤ (25°C, 40% RH):	$> 10^8$ Ω $> 10^{10}$ Ω (*Typical*)

a. Using the 44474A external increment & channel closed, display off.

.

■ AC ISOLATION / PERFORMANCE ($Z_L = Z_S$ = 50Ω or 75Ω)[a]		
Insertion Loss		
≤ 40°C, 95% RH:	≤ 10 MHz: ≤ 100 MHz: ≤ 500 MHz: ≤ 1.3 GHz:	< 0.3 dB < 0.7 dB < 1.5 dB < 3.0 dB
≤ 25°C, 40% RH (*Typical*):	≤ 10 MHz: ≤ 100 MHz: ≤ 500 MHz: ≤ 1.3 GHz:	< 0.2 dB < 0.5 dB < 1.1 dB < 1.9 dB
Crosstalk[b]		
Channel-Channel, Channel-Common: (with 1 channel closed)	≤ 10 MHz: ≤ 100 MHz: ≤ 500 MHz: ≤ 1.3 GHz:	< -90 dB < -80 dB < -65 dB < -55 dB
Group-Group, Module-Module:	≤ 10 MHz: ≤ 100 MHz: ≤ 500 MHz: ≤ 1.3 GHz:	< -90 dB < -80 dB < -70 dB < -60 dB
VSWR:	≤ 10 MHz: ≤ 100 MHz: ≤ 500 MHz: ≤ 1.3 GHz:	< 1.20 < 1.25 < 1.35 < 1.55
Capacitance:	Center-Center: Center-Shield:	< 0.006 pF < 60 pF
Rise Time:	< 300 ps	
Signal Delay:	< 3 ns (channel matched to ±50 ps)	

a. $Z_L = Z_S$ = 50 Ω applies for the 44478A and $Z_L = Z_S$ = 75 Ω applies for the 44478B.
b. The CrossTalk specifications assume 50 Ω termination for the 44478A and 75 Ω termination for the 44478B. If all channels unterminated, derate specification by 6 dB.

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*If you have questions realated to the operation of the Agilent 3499A/B/C or plug-in modules, call **1.800.453.4844** in the United States, or contact your nearest Agilent Technologies Sales Office.*

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